UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Correlations within and between Markets and Commodities

Bachelor's Thesis in Financial Economics

IVAR NILSSON
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Abstract

With a growing interaction between markets, when all markets and exchanges are being influenced by the globalisation, the correlations between markets and commodity exchanges becomes an interesting topic. How are they related to each other is the question this study tries to answer. The study includes a large number of the largest national stock markets and some of the most important commodities trades world wide. Correlations analyses are conducted among these securities to find out what relationships that exists, sometime it also tries to pose possible reasons to the relationships.

Data time series for 33 different national stock markets and 17 commodities are analysed in terms of rate of return and standard deviation. Correlation analyses are conducted for the markets as well for the commodities, also correlations between the markets and the commodities are analysed. The study includes time series data updated both daily and quarterly for analysing both short and long term behaviours and relationships.

Some of the interesting results are presented below. During the time analysed, the study suggests that the Moroccan stock market and Gold have been the best performing assets in terms of risk adjusted return measured on a quarterly basis. If risk is not considered, the developing markets Brazil, Russia and Turkey have been the most lucrative investments. It can be shown in the study that the western countries are closely connected to each other. Markets for closed off countries such as China and Saudi Arabia show very little correlation to other markets. The American markets influences the most eastern countries, much more than the other way around. Metals used in alloys important for the industry have higher correlations to each other and towards the markets than other commodities, i.e. other metals, energy sources and soft goods that also are included in the study.

Keywords: Finance, Econometrics

Contents

Preface

This Bachelor's thesis project was carried out during 2012. A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Financial Economics at the School of Business, Economics and Law, Gothenburg University in Gothenburg, Sweden. The project was conducted at the Department of Economics and the Centre for Finance. Ivar Nilsson and Oskar Thulin have been responsible for writing this thesis, Professor Lars-Göran Larsson for supervision.

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Gothenburg, December 2012
Ivar Nilsson and Oskar Thulin

1 Introduction

Globalisation is forcing all the markets to be more closely interconnected, but which markets are more connected towards others? This information is useful for investors in order to diversify risk. By spreading assets among different securities that are not closely related to each other, the investor simply does not put all the eggs in one basket. In order to properly diversify the risk it is advantageous for the investor to have information about the rate of return, the standard deviation, the rate of return normalized by risk and the internal correlations between the prospected securities for investment. Standard deviation is seen as a quantitative measure of the historical risk. Since commodities are also available investments for an investor, information about commodities should also be included in the analysis side by side to the market data. The results can be utilized as descriptive data of the data collection, such as Sharpe Ratio [44]. An investor can also use the results in order to diversify risk according to the Modern Portfolio Theory, developed by Harry M. Markowitz. Using the expected rate of return and the risk from historical observations which is presented in this thesis, the investor can simply maximize the ratio between them by assigning optimum weightings of the portfolio components. The investor can then use this optimised portfolio to obtain the desired return to the lowest amount of risk, by using an appropriate leverage alternatively deleverage.

This thesis included analysis of data between 1994 and 2012, the data is analysed over the whole time period as one time interval. Analysing different time periods have been limited due to confinement of the thesis work, another bachelor's thesis conducted at the University of Gothenburg, School of Business, Economics and Law in 2008 covers how the correlations have changed over time [21]. The data in this thesis has been analysed for both short time intervals as well as long, daily and quarterly respectively. Basic time dependence analysis is also added for the indices in terms of measuring the correlation of one day lagged values, a more thorough analysis can be found in the bachelor's thesis by R. Falck and Lingefjärd which includes several time lags [11].

1.1 Objective

The objective of this thesis is to evaluate the behaviour of and relationships between national stock markets indices and commodities, both on a short term horizon as well as on long term.

1.2 Outline of Work and Report

This study have been limited to analyse the history of 18 years back, deep analysis of the underlying nature of the relationships are neglected due confinement of the work scope. Only national stock markets data is used, branches and individual stocks are not included to limit the size of the data handled and analysed in this study. In this study the time

series data have been collected using Datastream©by THOMSON REUTERS, the agency can be argued to be both reliable and independently distributed leading to that the outcome of the analysis is trustworthy. The time series data has been treated in Mathworks MATLAB®, a widespread commercial software for data modelling. This was the program of choice since it generally offers a rather swift implementation for time series data, sufficient performance and that previous experience using the program exist in the research group.

The disposition of the thesis is laid out as follows, first the theory of the statistical operations are thoroughly introduced. The data is thereafter presented for the markets and the commodities in the methodology section, the treatment of the data is also included in this section. The results are presented in the result section, including rate of return, standard deviation, return over risk and correlations matrices. Further, the discussion and conclusions of the results presented in the results section are placed in the discussion section. The limitations in the study and the recommendations for further work are also presented in the discussion section.

2 Theory

This section describes the statistical theories used for the thesis.

2.1 Return of an Asset

The return of an asset is defined as the percentage change in the value of an asset during a specific time interval. Mathematically the return of an asset, r_j, is calculated according to the following formula:

$$r_j = \frac{V_{i+1} - V_i}{V_i} \tag{2.1}$$

where V_{i+1} is the value of asset j at time $i+1$ and V_i is the value of the same asset at an earlier time i. The average return of an asset, $\bar{r_j}$, is obtained using the following expression:

$$\bar{r_j} = \frac{1}{N} \sum_{i=1}^{N} r_j \tag{2.2}$$

where r_j is the return of asset j from time $i-1$ to time i and N is the number of observations.

2.2 Variance and Standard Deviation

Variance is a statistical measure to describe how far different observations of a random variable are from the expected value of the variable. The general formula for the variance of the random variable x with an expected value of μ is according to [22]:

$$\mathrm{Var}\,(x) = \mathrm{E}\,(x-\mu)^2 \tag{2.3}$$

A high variance indicates that the observed values are scattered while a low variance indicates that the values are more similar. When examining the variance of the return of an asset, σ^2, from a data series, the following formula is used:

$$\sigma^2 = \frac{1}{N}\left[(r_1 - \bar{r})^2 + (r_2 - \bar{r})^2 + \cdots + (r_n - \bar{r})^2\right] \tag{2.4}$$

where N is the number of observations of the return. The standard deviation of an asset's return, σ, is defined as the square root of the variance of the return according to [22]:

$$\sigma = \sqrt{\sigma^2} = \sqrt{\frac{1}{N}\left[(r_1 - \bar{r})^2 + (r_2 - \bar{r})^2 + \cdots + (r_n - \bar{r})^2\right]} \tag{2.5}$$

2.3 Return Normalized by Risk

By letting the standard deviation act as an indicator of the risk of an asset, one can estimate the risk adjusted return, $\bar{r_j^*}$, by using the following equation.

$$\bar{r_j^*} = \frac{\bar{r_j}}{\sigma_j} \tag{2.6}$$

2.4 Covariance

Covariance is a statistical measure used to described how two variables varies together. A positive covariance value indicates that the greater values of one variable corresponds greatly to the greater values of the other variable and vice versa for the smaller values. The two variables tend to show a similar behavior and therefore the value of the covariance is positive. If the opposite phenomena is observed, i.e. the greater values of one variable corresponds to the smaller values of the other variables and vice versa, the covariance is negative. The general formula for the covariance between two variables, x and y, is according to [22]:

$$\mathrm{Cov}\left(x, y\right) = \mathrm{E}\left[\left(x - \mathrm{E}\left[x\right]\right)\left(y - \mathrm{E}\left[y\right]\right)\right] \tag{2.7}$$

When this formula is applied to calculate the covariance in the return of two different assets, $\sigma_{i,j}$, the following expression is used:

$$\sigma_{i,j} = \frac{1}{N}\sum_{k=1}^{N}\left(r_{i,k} - \bar{r_i}\right)\left(r_{j,k} - \bar{r_j}\right) \tag{2.8}$$

where $r_{i,k}$ is the return of asset i at observation k, $r_{j,k}$ is the return of asset j at the same observation and $\bar{r_i}$ and $\bar{r_j}$ are the average returns of assets i and j respectively.

2.5 Correlation Coefficient

A more intuitive measurement of the interaction between two variables is the correlation coefficient. It describes how strong the linear relation between two variables is as a value between 1 and -1. A value of 1 indicates that there is a perfect positive linear correlation between the two variables, i.e. all the observations lie on a straight line with positive slope. A value of -1 indicates instead that there is a perfect negative linear correlation between the two variables and all observations lie on a straight line with negative slope. The strength of the linear relationship is determined by the absolute value of the correlation. A correlation coefficient of close to ± 1 indicates that the correlation is strong while values close to 0 indicates a weak correlation. A correlation coefficient of 0 indicates that there is no linear relationship between the two variables. There are many ways to calculate the correlation coefficient, but one of the most common is the *Pearson's product-moment coefficient*. Its mathematical formulation applied to the return of two assets, i and j, is according to [22]:

$$\rho_{i,j} = \mathrm{Corr}\left(r_i, r_j\right) = \frac{\mathrm{Cov}\left(r_i, r_j\right)}{\sigma_i \cdot \sigma_j} = \frac{\sigma_{i,j}}{\sigma_i \cdot \sigma_j} \tag{2.9}$$

where $\rho_{i,j}$ is the correlation coefficient between the two assets. When the correlations between a set of different variables are calculated and compared, a simple way to present them are by a so called correlation matrix. If the correlation of n variables are compared, e.g. the returns r_1 to r_n, the correlation matrix has the size of $n \times n$ elements. The value of the i, j element in the matrix is the value of $\text{Corr}\,(r_i, r_j)$.

2.6 Index

An index is a statistical measure which describes how certain statistical properties of e.g. assets or commodities have changed over a period of time. Every index has an exclusive definition which describes how its value is calculated. Its initial value, called base value, is defined at a certain point in time and the value of the index is then evaluated at continuous time intervals. This makes it possible to examine how the underlying securities included in the definition of the index has performed over time. It is usually of larger interest to know the percentage change of the index value rather than its absolute value.

A stock index is calculated using a fictional portfolio consisting of a specified number of stocks of specified weights. The value of the stock index is then obtained by evaluating the percentage change of the fictional portfolio and apply that change to the stock index value.

2.7 Commodity

A commodity is a basic good for which there is a demand on the market. There is no or only marginal differences in the good produced by different producers and the good is therefore interchangeable with commodities of the same sort.

Commodities are usually traded using standardized futures contracts, where the quantity and minimum quality of the commodity is specified. The price of the futures contracts for the commodities are determined by supply and demand and are traded at special commodity markets, so called commodity exchanges.

3 Methodology

In this section the used time series data are presented. First the stock markets and later on the commodities. The methodology in integrating, model and treating the data is presented last in the section.

3.1 Data Description

All indices and commodities have been collected using Datastream©by THOMSON REUTERS. When possible, the data has a duration of 18 years. Reaching from 1994-04-20 alternatively when the indices was introduced, to the 2012-04-20. All indices has been recalculated to United States Dollars(USD) equivalents in order to enable a comparison without influence of the spot rate. The data includes 33 national stock market indices of the largest stock markets in the world and 17 commodities important for the world economy. The market indices have been collected to reflect the national markets to best degree possible, either by that the index is commonly seen as the main index of the market and/or that it comprises of a significant portion of the trades capturing the movement of the stocks listed at the exchange.

3.1.1 Stock Market Indices

The indices have been chosen to represent the largest and most influential stock market around the world. Every index is stated with Country - Full name (abbreviation if any), they follow below.

Australia - Standard & Poors / Australian Securities Exchange (S&P/ASX 200) [48]

S&P/ASX 200 is an index started in 2000 reflecting the movement of the 200 largest stocks at the Australian Securities Exchange (ASX). The benchmark index is widely considered to be the most prominent on the Australian stock market. Free-float adjustment is considered for this index, i.e. it only includes the number of stocks that are available for the market. The index covers 78% of the Australian equity market capitalization and is maintained by three representatives from S&P and two from ASX.

Austria - Wiener Börse Index (WBI) [62]

The WBI index is created from all domestic stocks at the Wiener Börse and was started in 1967.

Brazil - Bovespa Index [2]

The Bovespa Index has been issued since 1968 and represents the 50 most traded stocks at São Paulo Stock Exchange. The index is the main indicator of the Brazilian stock market's average performance.

Canada - Standard & Poors / Toronto Stock Exchange Composite (S&P/TSX Composite)

S&P/TSX Composite is an index including the largest companies at the Toronto Stock Exchange (TSX) and it is the broadest among the S&P/TSX variants. It was launched in 1977 and is maintained by four representatives from S&P and three from TSX.

China - Shanghai Stock Exchange (SSE) A Share [43]

The Shanghai Stock Exchange (SSE) is the fifth largest stock market in terms of market capitalization. SSE consist of two different types of stocks. First, type A which international investors were unable to trade before 2001 and after 2001 with some limitations. Type B allows for international investments and is listed in $US instead of the Yuan. The A shares are highly dominant in terms of market capitalization, the A share index has therefore been chosen for the analysis. It was launched in 1992 with a base date set to 19th of December 1990, the index consists of all shares of type A at SSE.

Denmark - OMX Copenhagen 20 (OMXC20) [34]

The OMXC20 consists of the 20 most traded shares among the 25 largest companies listed on the Nasdaq OMX Copenhagen. The index is free float adjusted to reflect the shares that are available for investors. The index was issued the first time in 3rd of July 1989.

Egypt - Egyptian Exchange 30 (EGX 30) [10]

EGX 30 is consisting of the 30 most capitalized and liquid stocks on the Egyptian Exchange. The index started in 2003 and the base date was set to first January 1998.

France - Cotation Assistée en Continu 40 (CAC 40) [38]

Consists of the 40 representative stocks on the Euronext Paris stock exchange based out of free float adjusted market capitalization and turnover. The index has been calculated since the year of 1987.

Germany - Deutscher AktienindeX 30 (DAX 30) [9]

DAX 30 contains the 30 largest and best-performing companies on the Frankfurt Stock Exchange. The index has been issued since 1987 and its composition is based on free float stocks market capitalization.

Hong Kong - Hang Seng Index (HSI) [17]

HSI was launched in 1969, the index gives a measure of the performance of the largest and most influential companies at the Stock Exchange of Hong Kong. No precise quantity is set, the companies has to fulfill a number of requirements to be included.

Hungary - Budapest Stock Index (BUX) [6]

BUX has been issued since 1991 and consist of the largest free float constituents of the listed companies at the Budapest Stock Exchange in terms market capitalization. At most, 25 companies are included but it can also be less.

India - Bombay Stock Exchange 100 (BSE-100)) [4]

Includes the 100 largest companies based on free float market capitalization on the Bombay Stock Exchange. The index was launched in 1991.

India - Standard & Poors / Credit Rating Information Services of India Limited (CRISIL) and the National Stock Exchange of India (NSE) 500 (S&P CNX 500)) [36]

Consists of the 500 largest stocks at the National Stock Exchange of India (NSE) in Mumbai, the index is based on free float market capitalization. The index has its base date set to the first trading day of 1994.

Israel - Tel Aviv 100 (TA-100) [49]

TA-100 comprises of the 100 largest companies at the Tel-Aviv Stock Exchange (TASI) in terms of market capitalization and was launched in January 2 1992.

Italy - FTSE Borsa Italiana (FTSE MIB) [5]

FTSE MIB Index includes 40 of the leading companies listed on Borsa Italiana (BIt), it was launched in 2003 but back calculated to December 31 1997.

Japan - Nikkei 225 [37]

Nikkei 225 is the most popular benchmark of Japanese market, it consists of 225 companies included based on high liquidity and sector balance. The index was launched in 1950 and the constituents are reviewed annually.

Morocco - Moroccan All Shares Index (MASI) [7]

MASI includes all companies listed on the Casablanca Stock Exchange, the base date of the stock was set to 31st December 1991.

Norway - Oslo Stock Exchange All Share Index (OSEAX) [40]

OSEAX consist of all the stocks listed on the on Oslo Børs, it has been issued for a longer time than the duration of this study.

Poland - Warsaw Stock Exchange Index (WIG)[61]

WIG has been calculated since 1991, the index comprises all companies listed on the Warsaw Stock Exchange.

Russia - Moscow Interbank Currency Exchange (MICEX) [32]

MICEX index consists of the 30 major and most liquid Russian stocks listed at the MICEX Stock Exchange. The index has been calculated since September 22 1997.

Saudi Arabia - Tadawul All Share Index (TASI) [1]

Consist of closely to all shares listed on the Saudi Stock Exchange except a few with smaller trades than a certain threshold. The index was launched in 1985.

Singapore - FTSE Straits Times Index (STI) [14]

Consists of the top 30 companies listed of the Singapore Exchange ranked by market capitalization. The index has a history that goes back to 1966 and is free float adjusted. The index is jointly managed by Singapore Press Holdings (SPH), Singapore Exchange (SGX) and FTSE Group (FTSE).

South Africa - FTSE/Johannesburg Stock Exchange Africa All Share Index (FTSE/JSE) [13]

The FTSE/JSE index is managed by FTSE and the Johannesburg Stock Exchange (JSE) and includes all stock listed on JSE except a few that doesn't meet some small thresholds on trades and minimum free float. The base date was set to 21st of June 2002 and the index is free float adjusted.

Spain - Madrid Stock Exchange General Index (IGBM) [3]

IGBM is the principal index i Spain and includes all companies listed on the Madrid Stock Exchange. The index was launched in 1985.

Sweden - OMX Stockholm 30 (OMXS30) [35]

The OMXS30 comprises of the 30 most traded stocks on the OMX Stockholm Exchange and is seen as the main index of the exchange. The index was started in 1986.

Switzerland - Swiss Performance Index (SPI) [45]

SPI is a all share index of stocks with free float portions larger than 20% and the main index of the SIX Swiss Exchange. The index is free float adjusted and was launched in 1987.

Taiwan - Taiwan Capitalization Weighted Stock Index (TAIEX) [60]

The TAIEX index includes all companies listed at the Taiwan Stock Exchange Corporation (TWSE). It is the most quoted of all TWSE indices and has been published since 1967.

Thailand - Bangkok Stock Exchange of Thailand (SET) Index [58]

SET consists of all common stocks listed at The Stock Exchange of Thailand, the base date was set to April 30 1975.

Turkey - Istanbul Stock Exchange National 100 Index (ISE National 100 Index) [54]

The index was introduced in 1986 covering 40 selected stocks at The Istanbul Stock Exchange (ISE), later on it was altered to include 100 companies.

Great Britain - FTSE All-Share Index [12]

Incorporates all shares on the London Stock Exchange, the index is free float adjusted. The index was launched 1962 and accounts 10% of the world's equity market capitalization.

United States - Dow Jones Industrial Average (DJIA) [46]

Includes 30 well-known United States companies in all industries except Transportation and Utilities. The included companies are mainly listed at the New York Stock Exchange (NYSE), in some cases also at the NASDAQ Stock Market. The index is one of the most quoted United States indices and is maintained and composed by a committee. The index was first calculated on May 26 1896.

United States - NASDAQ Composite [33]

The NASDAQ Composite includes all stocks listed on The NASDAQ Stock Market by free float market capitalization. It includes over 3000 securities and was launched in 1971.

United States - New York Stock Exchange Composite (NYSE Composite) [39]

The NYSE Composite Index captures the movement of all stocks listed on the New York Stock Exchange (NYSE). It consists of over 2000 stocks and was launched 1965.

3.1.2 Commodities

The commodities have been collected targeting spot/cash price assets. If cash equivalents have not been possible to collect, the shortest duration has been preferred to reflect the current financial market as good as possible.

Aluminum - London Metal Exchange (LME) Aluminum 99.7% - Cash US$/M.T. [24, 23, 29]

Aluminum is an important metal used in various light weight structures, the LME Aluminum commodity is updated daily and the price is valid for lots of minimum 25 metric tonnes (M.T.) Aluminum became lately the most traded contract at LME. The commodity issuer LME has been operating since 1877 and is the dominant center for trading metals with 80 % of the all non-ferrous metal futures worldwide transacted at their trading platforms.

Coal - The Hamburg Institute of International Economics (HWWI) Index of World Market Prices: Coal - Price Index [63, 15, 16]

Coal is one of the most used energy source worldwide, during year 2011 it stood for 30.3 % of the total energy consumption and 42 % of the total electricity production. HWWI has published daily data on a weekly basis since April 1996 and the institute has monthly data from 1979. HWWI is commonly referred to by Federal bank, OECD and IMF.

Cocoa - The International Cocoa Organization (ICCO) Daily Price - US$/M.T. [51, 52, 53]

Cocoa, being the main ingredient in chocolate is an important commodity in the candy industry with large companies such as Kraft Foods Inc, Mars Inc and Nestlé SA. ICCO was established in 1973, and since that point is has been handling international cocoa agreements. ICCO publish daily price data of cocoa, before September 1995 the update frequency was weekly instead of daily.

Coffee - IntercontinentalExchange (ICE) Coffee Brazilian - US¢/lb [50]

ICE acquired the New York Board of Trades in 2007 and became thereby the center of global trading in "soft" commodities. The ICE coffee commodity has its origin in 1887, when the Coffee, Sugar and Cocoa exchange was founded, this former unit is now incorporated in ICE. Coffee is one of the most traded commodity and is changing in value relatively frequently. The contract size is for 37500 lbs and the price is updated daily.

Copper - London Metal Exchange (LME) Copper Grade A Cash - US$/M.T. [25, 28]

Copper is commonly used in electronics, electrical wiring, plumbing, heating and ventilation applications. The contract is based on 25 M.T. lots and is updated daily.

Cotton - Standard & Poors GSCI Cotton Spot - Price Index [47]

Standard & Poors offers indices of different commodities, the GSCI family of indices were formerly known as the Goldman Sachs Commodity Index and thereby the GSCI abbreviation. The cotton index is screening the trades at ICE, is updated daily and the base date was selected to January 2, 1970.

Gold - London Market Bullion (LMB) Gold Fixing - US$/Troy Ounce [55]

LMB is the main trade exchange for Gold and the history goes back to the 17th century. The Gold Fixing has been issued since 1919 and is updated twice daily.

Lumber - Random Lengths (RL) Framing Lumber Composite Price - US$ [41]

Random Lengths has history back to 1944 but the data obtained in this thesis only covers back to 2004 and is updated weekly, thereby it shall not be used for any short term correlations.

Natural Gas - Henry Hub Natural Gas (NG) Spot Price - US$/mmBTU [42]

Henry Hub is distribution hub for natural gas located in Earth, Louisiana and it is owned by Sabine Pipe Line LLC a subsidiary of Chevron Corporation. In late 1989, the hub was selected by the New York Mercantile Exchange, now incorporated in CME Group, to be the official delivery mechanism for the world's first natural gas future contract. The index was before 1997 updated weekly and later daily.

Nickel - London Metal Exchange (LME) Nickel Cash - US$/M.T. [26, 31]

Nickel is an important metal used in stainless steel to maintain physical and mechanical properties under extreme temperatures, nickel also resists corrosion. Nickel has been traded at LME since April 1979 and lots come in quantities of 6 M.T.

Oil - IntercontinentalExchange (ICE) Crude Oi Monthly Brent Free on Board (FOB) - US$/barrel [19, 18]

Brent crude oil is traded based on the underlying market of Brent-Froties-Oseberg-Ekofisk oil fields, it has been a basis for futures since 1988. It is the dominant indicator of the oil price worldwide with two thirds of the world's oil trades based on the index. The index is updated daily, the type is a front month contract and the underlying contract size amounts

to 1000 barrels.

Platinum - The London Platinum & Palladium Market (LPPM) Platinum Fixing - US$/Troy Ounce [56]

Platinum is used nowadays in catalytic converters, special electrical components, dentistry equipment and jewelery . The London Platinum & Palladium Market was established in 1987 an the Fixing is updated daily.

Silver - London Market Bullion (LMB) Silver Fix Cash - US$/Troy Ounce [57]

The Silver Fixing was first establish in 1987, is now traded at the LMB and is updated daily.

Sugar - International Sugar Organization (ISA) Sugar Daily Price - US¢/lb [20]

ISA exists to handle the International Sugar Agreement negotiated in 1992 and is covering 95 % of the world's export on sugar. The organization also publish daily prices.

Uranium - The Ux Consulting Company (UxC) U_3O_8 Price - US$/lb [59]

There is no formal exchange for uranium but The Ux Company LLC monitor market activities. They publish the U_3O_8 Price indicator. The Price indicator is the longest running indicator which two decades of history. It is nowadays updated on a weekly basis, before June 2006 it was updated on a monthly basis.

Wheat - Chicago Mercantile Exchange (CME) Group USDA No.2 Soft Red Winter Wheat - US¢/Bushel [8]

Wheat is traded at the CME Group in many different variants but similar market movements. The USDA No.2 Soft Red Winter Wheat was selected to represent Wheat in general and is updated daily.

Zinc - London Metal Exchange (LME) Zinc 99.995% Cash - US$/M.T. [27, 30]

Zinc is commonly used in galvanizing of steel structures for corrosion protection purposes, also a component in brass besides copper. The index is updated daily and is traded in lots of 25 M.T.

3.2 Computational Data Analysis

This section gives a detailed explanation of the methodology and techniques used to perform the different analyzes of the data.

3.2.1 Data Integration and Modeling

The necessary data needed to perform the desired return and correlation analyzes was first obtained using the Datastream® software. The different markets and commodities were found by using the search functions within the program. The data was then downloaded and exported to Excel® as comma separated values (.csv) files to enable storage and reading of the data.

To be able to treat and perform calculations based on the data, the .csv files was first read using MATLAB®. Thereby the data could be converted to a more easily readable file format; the MATLAB® formatted binary file (.mat) file format. This greatly reduces the time necessary to read and manipulate the data when performing calculations based on the data.

3.2.2 Treatment of Data

The first step of the calculation process was to read the data into a MATLAB® program. The data for each index was read from the produced .mat files and was formatted as two column vectors containing the index spot values and the respective points in time. The rate of return for each of the indices could then be obtained using Equation 2.1. The result of the calculation was a vector containing the rate of return between each time point for all of the indices. The lengths of the vectors were therefore of length $N - 1$, where N is the length of the vector containing the observed spot values.

The vectors containing the rate of return for all of the indices were then formatted together into a matrix, with columns representing each of the indices' rate of return. Once this matrix was constructed, the correlation coefficients of the matrix columns could be calculated. This was achieved by the use of a function called *corrcoef* in MATLAB®. This function first calculated the covariance of the columns pairwise according to Equation 2.8. The covariance between all of the columns was then computed, including the covariance with respect to a column's own values. This special case is identified as the variance of the column, according to Equation 2.4. From the variance the standard deviation could be calculated using Equation 2.5. By dividing the rate of return for each index with its standard deviation the rate of return normalized to risk for each index could be calculated according to Equation 2.6. For some of the indices values were not available for the beginning of the examined time span. When calculating the covariance between two indices, only data for the mutual time span was used. A covariance matrix with diagonal values equal to the variance of the columns was then obtained. The size of the covariance matrix was $n \times n$, where n was the number of indices investigated. The variances were then used to calculate the standard deviations following Equation 2.5. Finally a correlation matrix could be calculated using the covariances and the standard deviations of each column by the use of Equation 2.9. Correlation matrices for the market indices, the commodity in-

dices and the correlation matrix between the market and commodity indices could then be identified as sections within the obtained correlation matrix for all of the indices.

The matrix obtained above described the unlagged correlation between the different indices, i.e. without respect to eventual time dependence in the correlation of the indices. In order to investigate the time dependency of the market indices, time lags were introduced in the collected data. This was achieved by shifting one of the indices' values by a number of steps representing the number of days it was lagged. New values for the correlation between the lagged index and the other unlagged indices were then calculated using the same methodology as before. Each index was lagged by one day so that eventual short term dependency in the correlations could be investigated between the markets.

4 Results

The results of the analyses within and between the markets and the commodities are presented below. The rate of return is initially presented. Secondly, the standard deviation of the data. At last, the correlation results are featured of the markets and the commodities within and between the data sets, the analysis is made both for daily data to analyse the short term behaviour and for quarterly data to examine long term behaviour. For the case of the markets, lagged daily data was also analysed to give indication of world wide dependence.

4.1 Rate of Return

The average rate of return of the examined markets is presented in Figure 4.1 on a quarterly basis and in Figure 4.2 on a daily basis. It can be seen that the markets having the highest rate of return are Brazil, Russia and Turkey while the markets having the lowest rate of return are Italy and Japan. Russia has the highest average return of quarterly basis at 6.71% while Brazil has the highest average return on a daily basis at 0.087%. Japan has the lowest rate of return and it has even been negative 0.14% on a quarterly basis. The Swedish market belongs to the average performing markets, with an average rate of return of 3.36% and 0.048% on a quarterly and daily basis respectively.

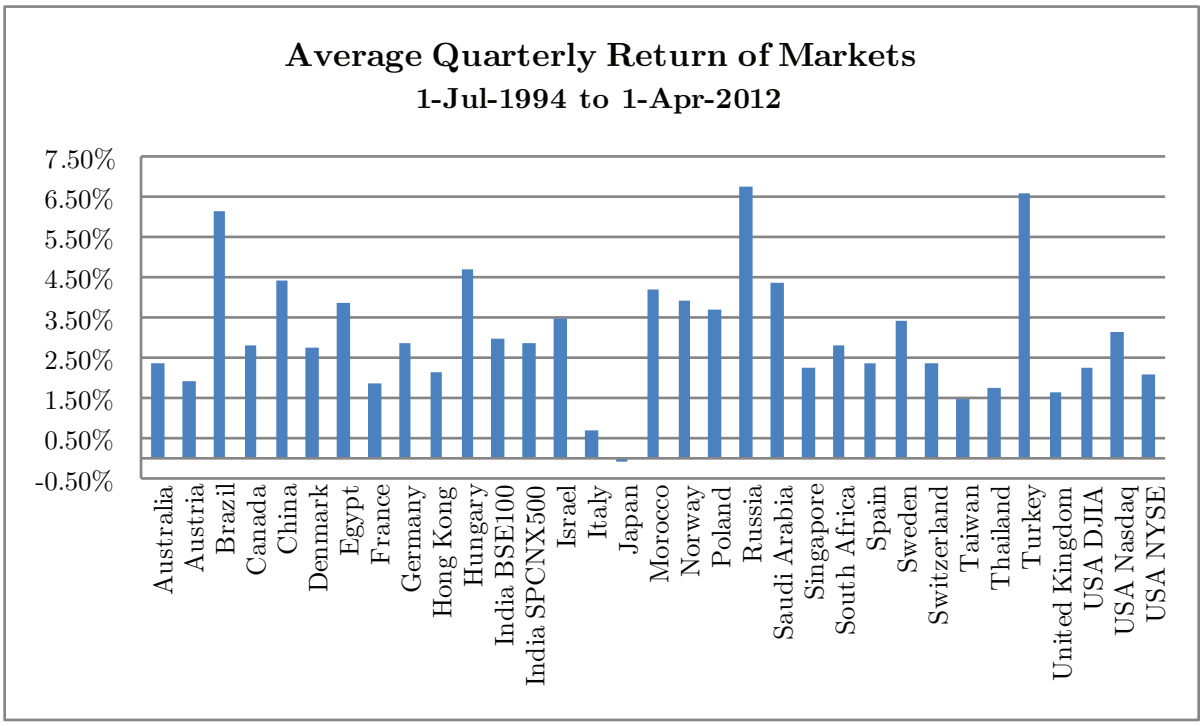

Figure 4.1: Diagram showing the average rate of return of the examined markets on a quarterly basis.

Figure 4.3 and Figure 4.4 illustrates the average rate of return of the commodities on a

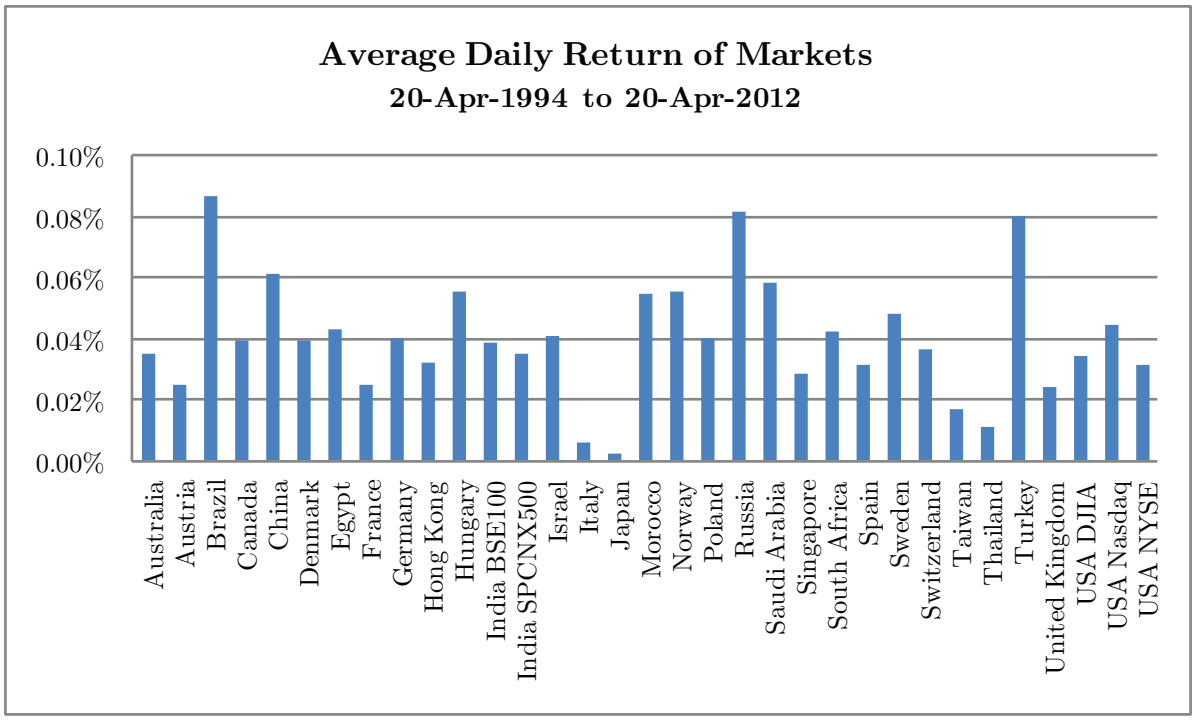

Figure 4.2: Diagram showing the average rate of return of the examined markets on a daily basis.

quarterly and daily basis respectively. Commodities connected to the energy sector, such as Natural Gas, Oil and Uranium have had the highest rate of return on a quarterly basis during the examined time period. Highest rate of return had Natural Gas at 5.96% on a quarterly basis. Aluminum, Cocoa, Coffee and Cotton have all had a rate of return below 1.50% while the worst rate of return was observed for Lumber, at -0.09% per quarter. On a daily basis, Lumber also performs poor, with -0.006% on average. It should be noted that the indices for Coal, Cocoa, Natural Gas, Lumber and Uranium are partially or entirely updated on a weekly basis for the examined time period. When the update frequency is less than daily for an index, the latest updated value is used for the following days until it gets updated again. This will to some extent affect the magnitude of the rate of return, when evaluated on a daily basis. The commodity which has had the highest rate of return on a daily basis is Sugar, with an average of 0.09% during the examined time period. After Sugar follows Natural Gas, with a rate of return of 0.079%, and Oil, with a rate of return of 0.068%. Cotton and Aluminum can be found among the commodities with lowest rates of return on a daily basis, with and average of 0.017 and 0.019% respectively.

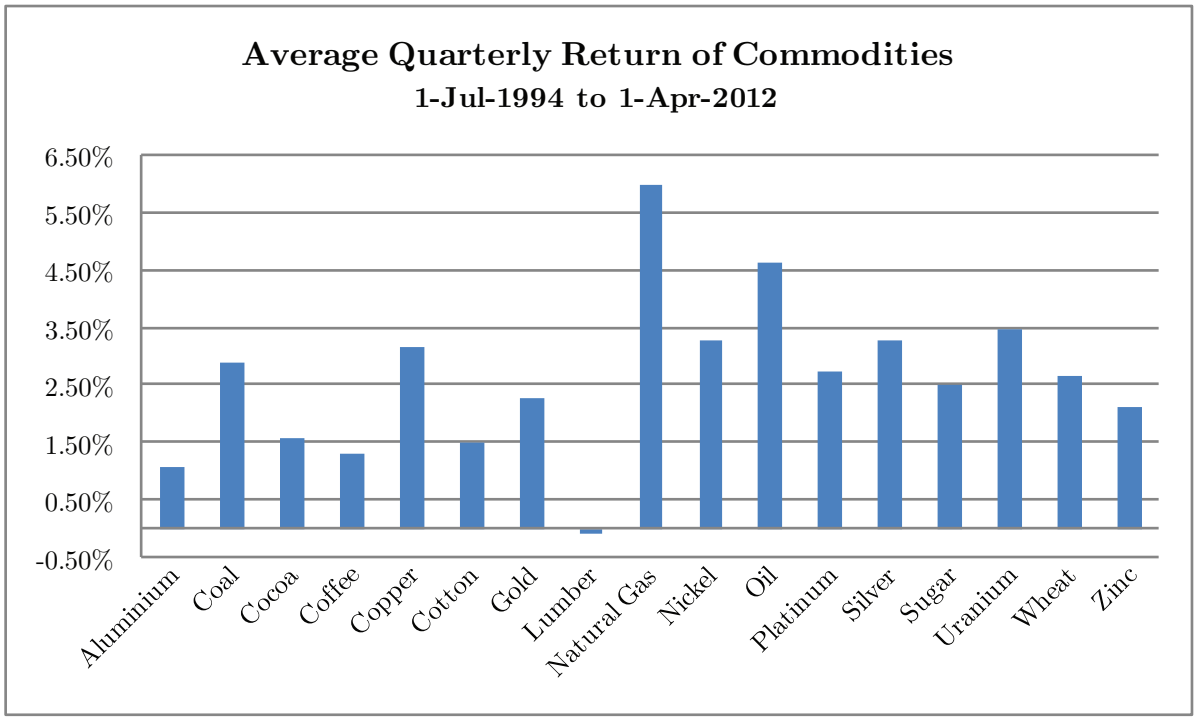

Figure 4.3: Diagram showing the average rate of return of the examined commodities on a quarterly basis.

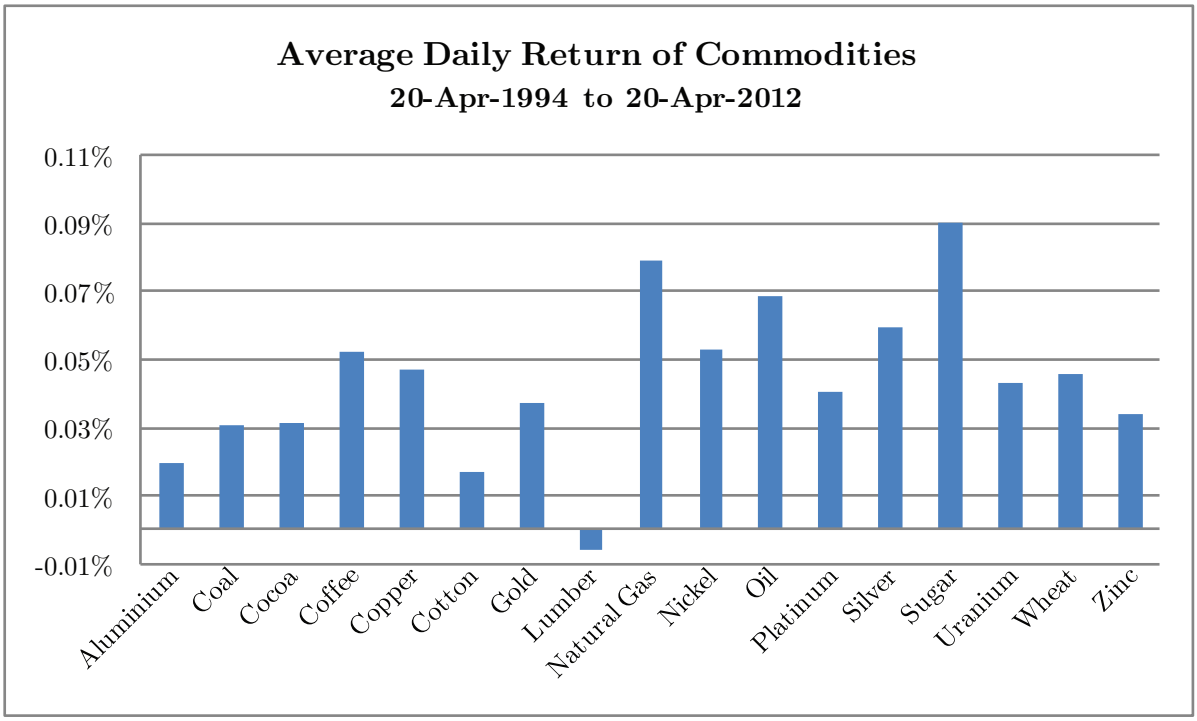

Figure 4.4: Diagram showing the average rate of return of the examined commodities on a daily basis.

4.2 Standard Deviation

The standard deviations in the rate of return for the markets is shown in Figure 4.5 on a quarterly basis and in Figure 4.6 on a daily basis. It can be seen that the markets with

the highest standard deviations on both a quarterly and daily basis are those of Turkey, Russia and Brazil, with quarterly values of 30.93%, 29.06% and 24.16% and daily values of 3.03%, 3.22% and 2.67% respectively. Lowest standard deviations are found for the American markets DJIA and NYSE on a quarterly basis with values of 8.47% and 8.99% respectively, followed by the United Kingdom and Switzerland with 9.96% and 10.06% respectively. On a daily basis also the Moroccan exhibit a low standard deviation at 1.01%.

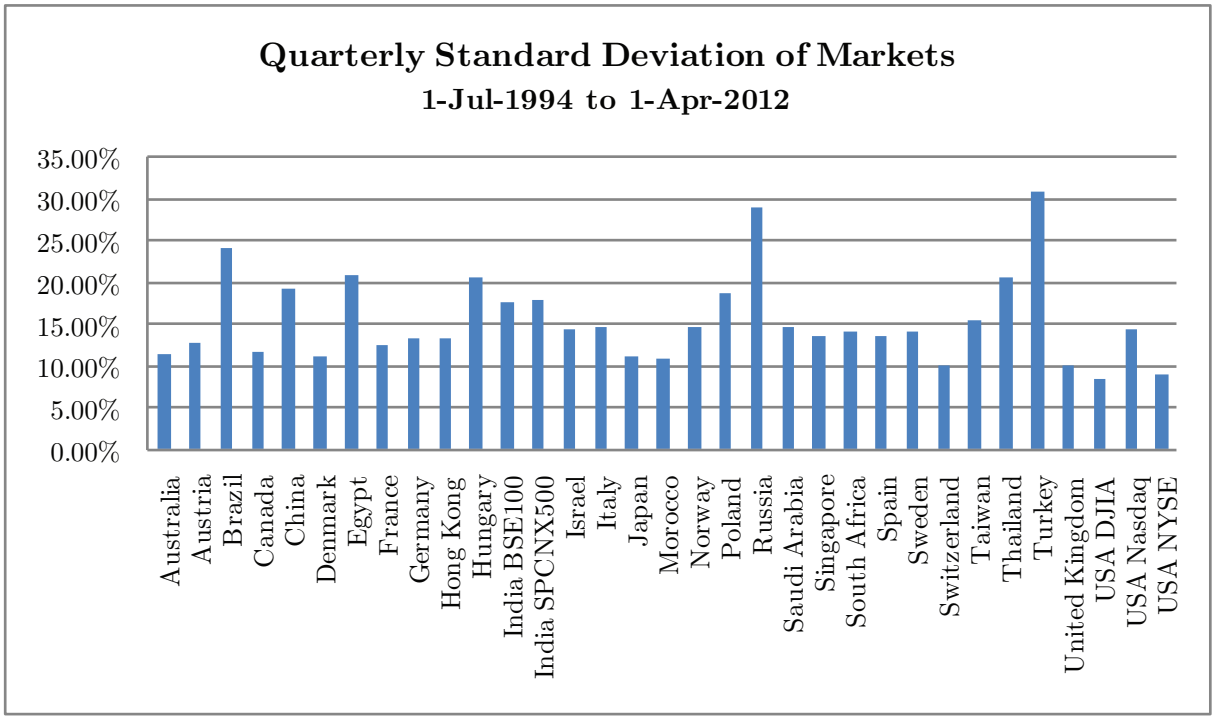

Figure 4.5: Diagram showing the standard deviation of the examined markets on a quarterly basis.

For the commodities, the quarterly and daily standard deviations are illustrated in Figure 4.7 and Figure 4.8. It can be seen that the highest standard deviation is found for Natural Gas with a quarterly value of 38.60% and a daily value of 4.08%. An interesting observation is that Sugar has a relatively moderate standard deviation on a quarterly basis at 17.65%, while it has the second highest on a daily basis at 3.88%. Gold is found among the examined commodities exhibiting the lowest standard deviations, with a quarterly value of 6.06% and a daily value of 1.02%. Lumber is another commodity exhibiting low standard deviations for both the quarterly and the daily analysis. As mentioned above it should be noted that for some of the commodities only weekly data has been available which will affect the daily standard deviations.

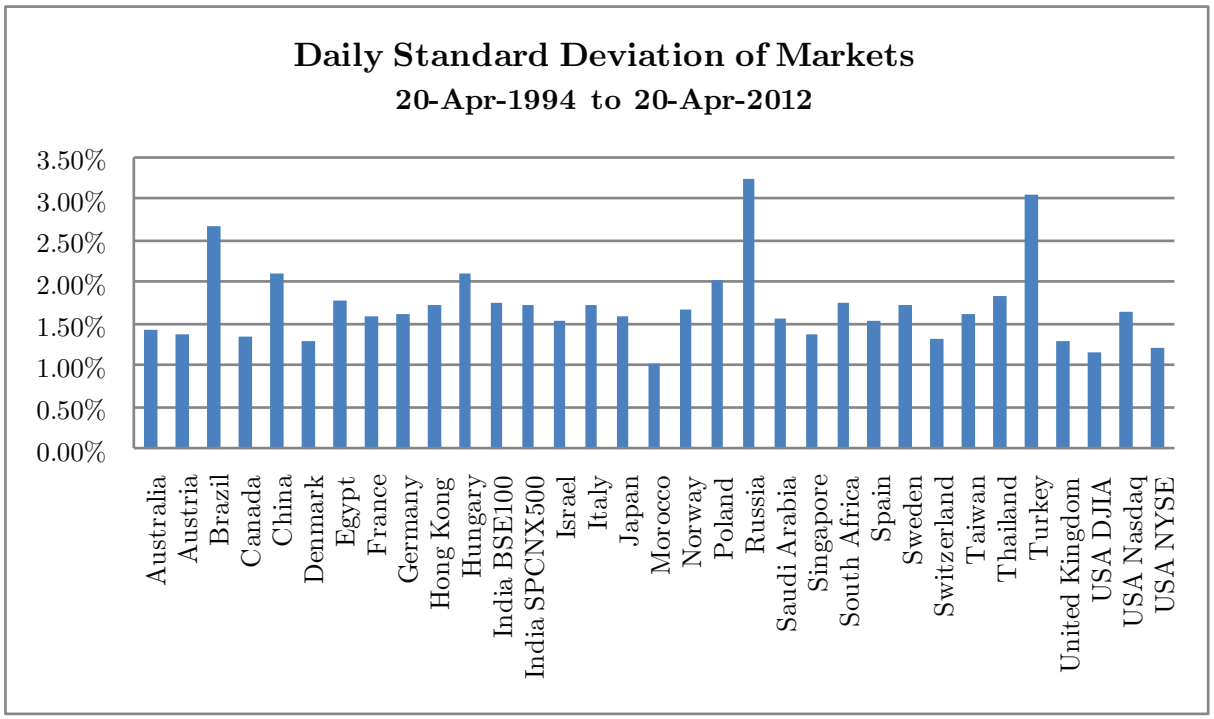

Figure 4.6: Diagram showing the standard deviation of the examined markets on a daily basis.

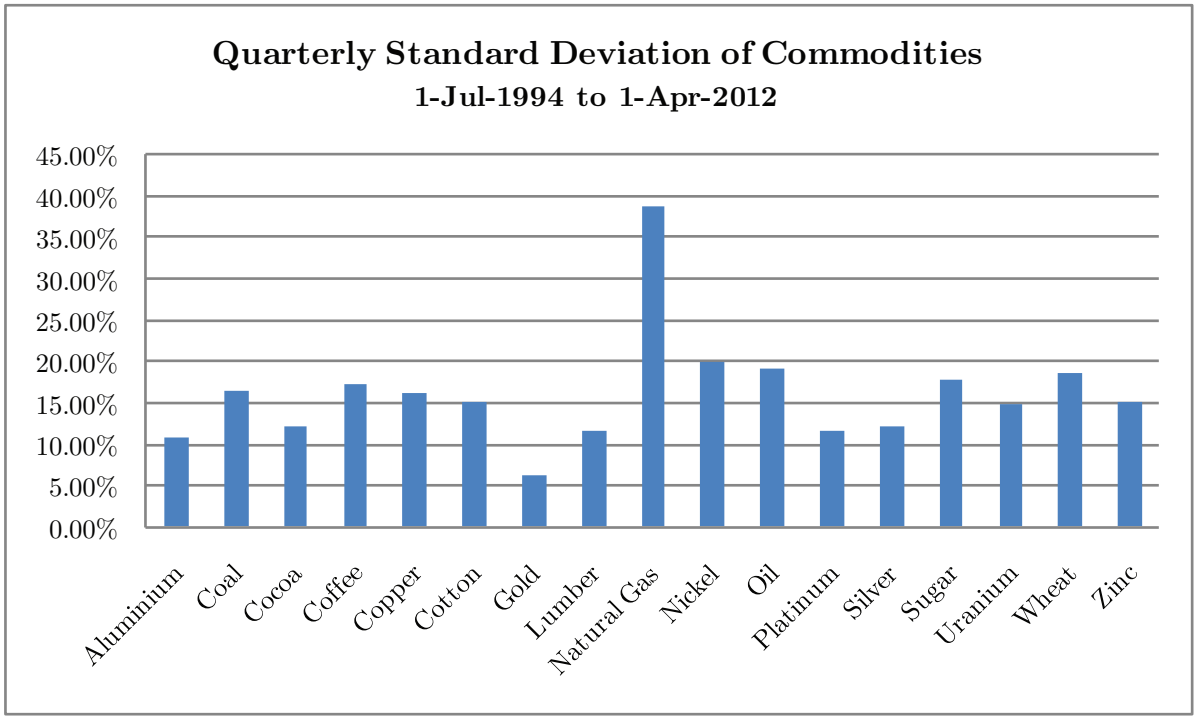

Figure 4.7: Diagram showing the standard deviation of the examined commodities on a quarterly basis.

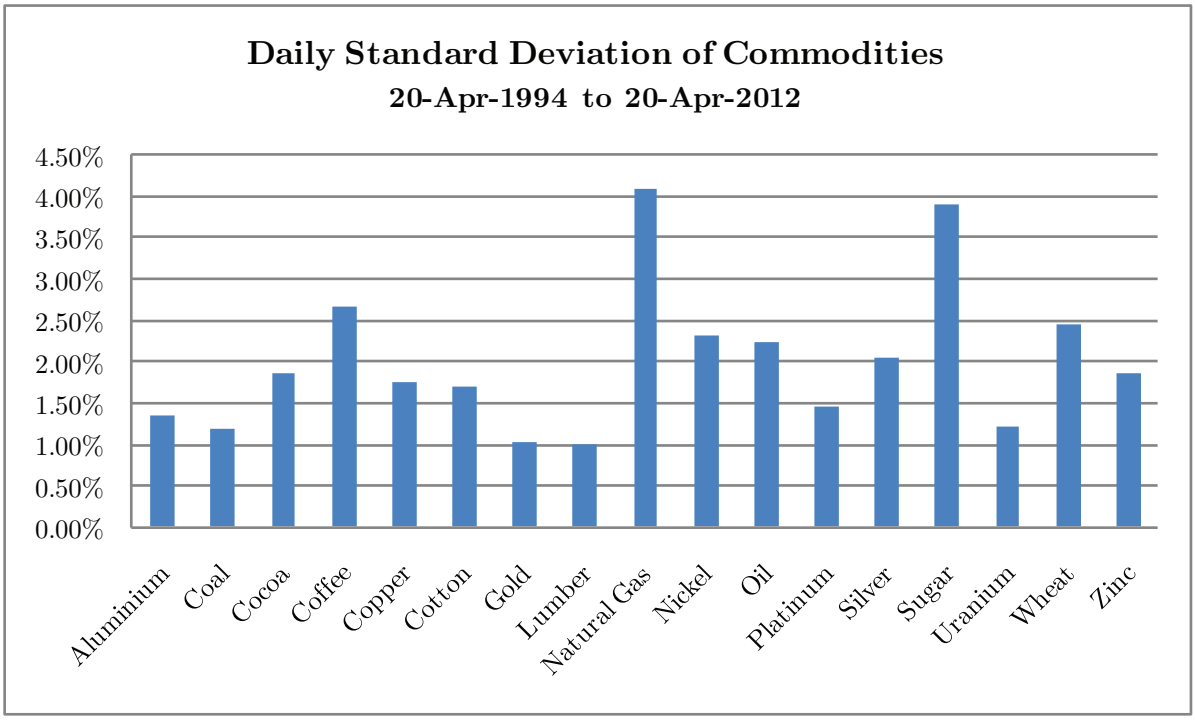

Figure 4.8: Diagram showing the standard deviation of the examined commodities on a daily basis.

4.3 Return Normalized to Risk

The returns for the markets normalized to their risk are presented in Figure 4.9 on a quarterly basis and in Figure 4.10 on a daily basis. The markets having the highest return contra risk on a quarterly basis are Morocco followed by Saudi Arabia and Norway with ratios of 0.381, 0.296 and 0.269 respectively. The lowest return contra risk is found for the markets of Japan, Italy, Taiwan and Thailand with ratios of −0.012, 0.045, 0.092 and 0.084 respectively. It can be seen that the markets having the highest return on a quarterly basis such as Brazil, Russia and Turkey, appear among the average performing markets when the return is normalized to the standard deviation. On a daily basis Morocco, Saudi Arabia and Norway are also having the highest return contra risk with ratios of 0.054, 0.037 and 0.033. Japan, Italy, Thailand and Taiwan are the markets having the lowest return contra risk on a daily basis with ratios of 0.001, 0.003, 0.006 and 0.010. The Swedish market is found among the upper average of the markets with a ratio of 0.238 on a quarterly basis and 0.028 on a daily basis.

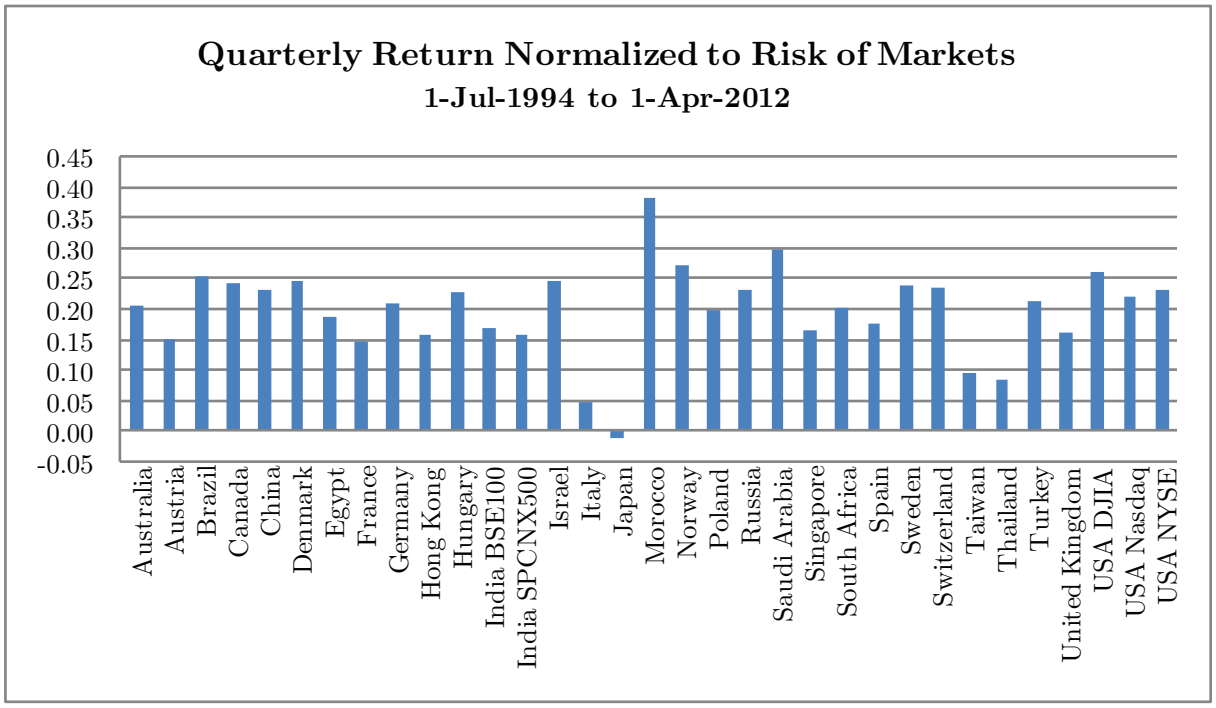

Figure 4.9: Diagram showing the return normalized to risk for the examined markets on a quarterly basis.

The returns for the commodities normalized to their risk are shown in Figure 4.11 on a quarterly basis and in Figure 4.12 on a daily basis. The highest return to risk on a quarterly basis is found for Gold with a ratio of 0.376 followed by Silver with a ratio of 0.270. On a daily basis Gold is also identified as the commodity having the highest return contra risk ratio of 0.036 closely followed by Uranium at 0.036 and Oil at 0.031. On both quarterly and daily basis Lumber is having the lowest return contra risk ratio at −0.008 and −0.006.

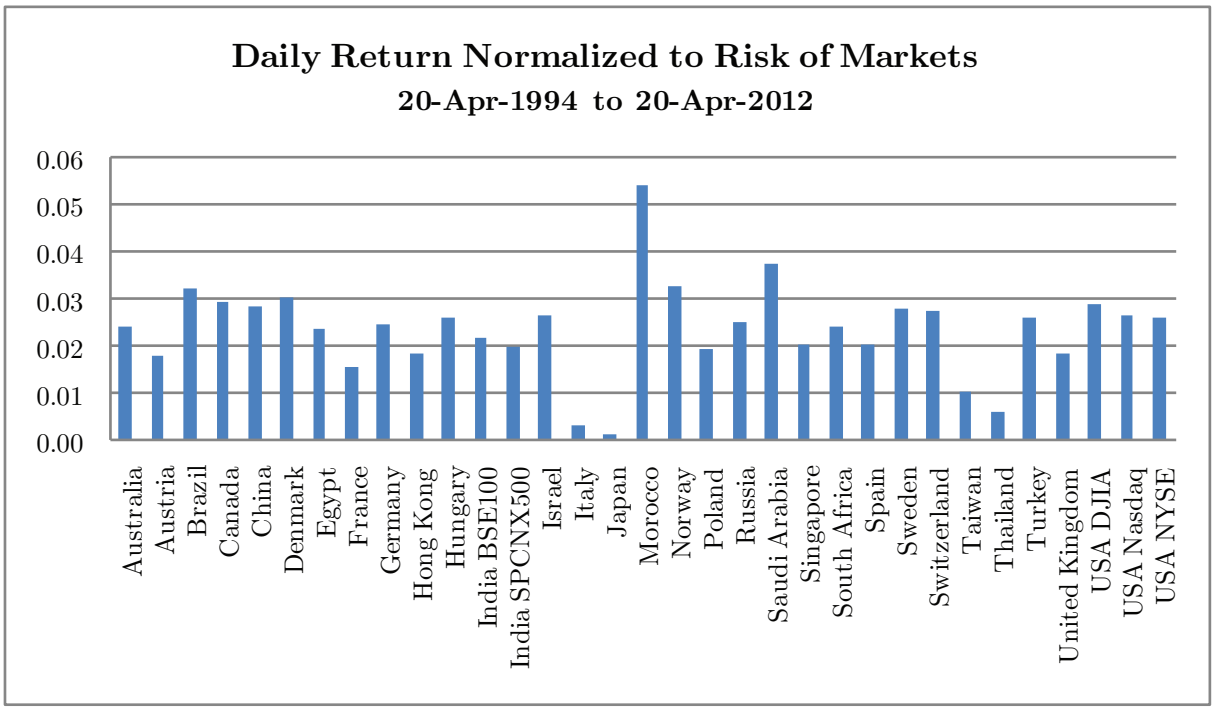

Figure 4.10: Diagram showing the return normalized to risk for the examined markets on a daily basis.

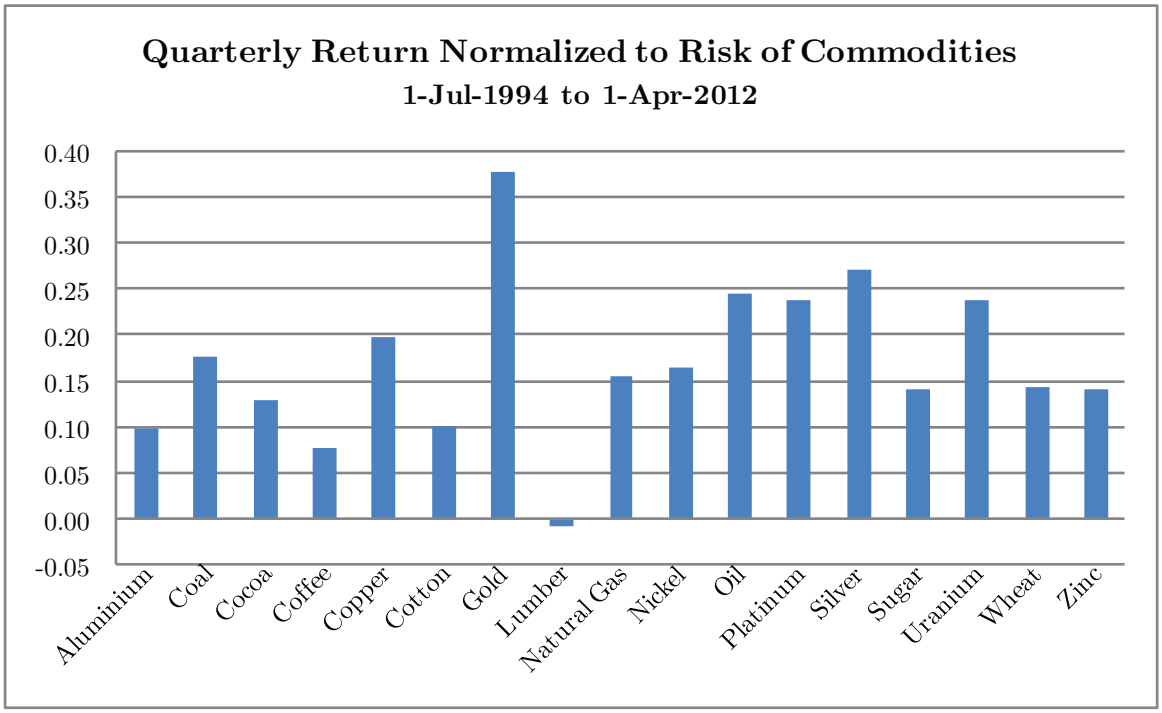

Figure 4.11: Diagram showing the return normalized to risk for the examined commodities on a quarterly basis.

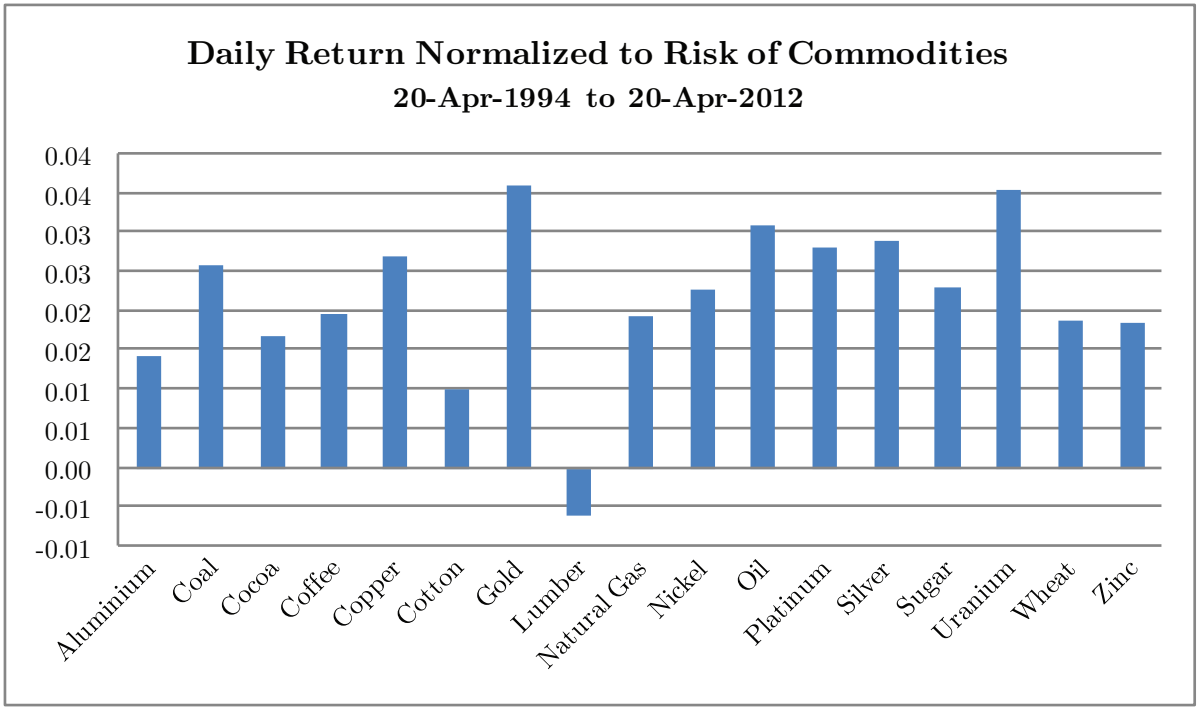

Figure 4.12: Diagram showing the return normalized to risk for the examined commodities on a daily basis.

4.4 Correlation

The calculated correlations is presented below. Firstly, the correlations between the examined markets is presented followed by the correlations for the examined commodities. Thereafter the correlations between the markets and the commodities is presented.

4.4.1 Market - Market

The unlagged correlation matrix on a daily basis of the market indices can be seen in Table 4.1. Overall, the correlations vary significantly for different countries. One market may be highly correlated to several other markets, such as the United Kingdom, while others are totally uncorrelated with the other examined markets, such as China. Generally it can be noted that European markets are relatively high correlated to each other, with several values above 0.6. Similar effects can be found in the markets of North America, between the American and Canadian markets. The highest correlations for the North American markets outside their local region can be found towards the western European countries, amounting to a maximum of 0.55. Overall, the correlations to other regions are relatively low for the American and Canadian markets.

The countries in the analysis having multiple domestic markets, i.e. India and USA, exhibit very high correlations between the domestic markets. Except for the domestic correlation, the correlations towards other countries are relatively low for the Indian markets. The only exception is towards Singapore. For the case of the Swedish market, highest correlations are seen towards France (0.818), Italy (0.799), United Kingdom (0.773), Germany (0.771), Spain (0.767), Denmark (0.746) and Norway (0.731), on a daily basis. This is consistent with the previously observed relationship between the European markets. Practically no correlation can be seen for neither of the Chinese, the Egyptian and the Saudi Arabian markets. For the case of China, the highest but still considerably low correlations are observed towards the Singapore and Hong Kong markets, with values below 0.24. The Australian market has a somewhat high correlation towards South Africa and Singapore. The markets of Taiwan, Turkey, Thailand, Israel, Japan, Switzerland and Morocco, exhibits a medium to low correlation towards the other markets, with values typically below 0.30.

Table 4.1: Correlation matrix based on daily samples between markets. Note that the matrix is symmetric.

	Australia	Austria	Brazil	Canada	China	Denmark	Egypt	France	Germany	Hong Kong	Hungary	India BSE100	India SPCNX500	Israel	Italy	Japan	Morocco	Norway	Poland	Russia	Saudi Arabia	Singapore	South Africa	Spain	Sweden	Switzerland	Taiwan	Thailand	Turkey	United Kingdom	USA DJIA	USA Nasdaq	USA NYSE
Australia	1.000	0.540	0.288	0.435	0.134	0.565	0.219	0.468	0.445	0.551	0.448	0.349	0.342	0.313	0.480	0.472	0.329	0.557	0.430	0.367	0.190	0.615	0.611	0.468	0.499	0.320	0.378	0.340	0.286	0.526	0.184	0.149	0.247
Austria	0.540	1.000	0.328	0.483	0.108	0.729	0.198	0.671	0.648	0.336	0.593	0.294	0.292	0.367	0.702	0.272	0.407	0.707	0.531	0.410	0.179	0.471	0.629	0.695	0.655	0.504	0.233	0.250	0.346	0.668	0.293	0.219	0.388
Brazil	0.288	0.328	1.000	0.507	0.041	0.411	0.101	0.443	0.430	0.240	0.322	0.207	0.193	0.257	0.476	0.106	0.195	0.409	0.307	0.284	0.106	0.368	0.449	0.431	0.421	0.184	0.149	0.184	0.272	0.452	0.489	0.455	0.536
Canada	0.435	0.483	0.507	1.000	0.054	0.534	0.112	0.600	0.586	0.301	0.453	0.256	0.242	0.348	0.591	0.191	0.239	0.583	0.419	0.342	0.133	0.385	0.546	0.559	0.585	0.310	0.183	0.230	0.292	0.614	0.618	0.614	0.713
China	0.134	0.108	0.041	0.054	1.000	0.111	0.083	0.063	0.063	0.186	0.066	0.125	0.125	0.041	0.088	0.097	0.122	0.095	0.072	0.102	0.088	0.234	0.126	0.058	0.067	0.045	0.107	0.095	0.046	0.069	0.009	0.010	0.027
Denmark	0.565	0.729	0.411	0.534	0.111	1.000	0.169	0.740	0.689	0.364	0.574	0.323	0.320	0.416	0.733	0.272	0.402	0.743	0.586	0.391	0.168	0.504	0.642	0.727	0.746	0.481	0.247	0.254	0.369	0.719	0.323	0.270	0.416
Egypt	0.219	0.198	0.101	0.112	0.083	0.169	1.000	0.128	0.134	0.184	0.160	0.204	0.209	0.153	0.138	0.178	0.131	0.176	0.176	0.126	0.141	0.226	0.178	0.131	0.132	0.099	0.135	0.149	0.130	0.156	0.068	0.051	0.087
France	0.468	0.671	0.443	0.600	0.063	0.740	0.128	1.000	0.855	0.329	0.566	0.283	0.271	0.435	0.901	0.211	0.327	0.703	0.517	0.398	0.141	0.457	0.649	0.864	0.818	0.407	0.198	0.224	0.343	0.840	0.480	0.410	0.558
Germany	0.445	0.648	0.430	0.586	0.063	0.689	0.134	0.855	1.000	0.345	0.549	0.262	0.261	0.421	0.837	0.208	0.290	0.666	0.504	0.382	0.144	0.425	0.621	0.788	0.771	0.391	0.191	0.226	0.340	0.775	0.510	0.457	0.572
Hong Kong	0.551	0.336	0.240	0.301	0.186	0.364	0.184	0.329	0.345	1.000	0.349	0.376	0.364	0.287	0.316	0.440	0.183	0.382	0.350	0.330	0.173	0.699	0.447	0.308	0.359	0.112	0.400	0.421	0.236	0.377	0.177	0.168	0.211
Hungary	0.448	0.593	0.322	0.453	0.066	0.574	0.160	0.566	0.549	0.349	1.000	0.276	0.261	0.376	0.608	0.226	0.331	0.577	0.584	0.436	0.148	0.419	0.599	0.579	0.567	0.331	0.190	0.241	0.371	0.556	0.283	0.243	0.352
India BSE100	0.349	0.294	0.207	0.256	0.125	0.323	0.204	0.283	0.262	0.376	0.276	1.000	0.969	0.226	0.307	0.205	0.157	0.328	0.289	0.250	0.090	0.499	0.343	0.275	0.307	0.137	0.258	0.266	0.220	0.309	0.166	0.151	0.204
India SPCNX500	0.342	0.292	0.193	0.242	0.125	0.320	0.209	0.271	0.261	0.364	0.261	0.969	1.000	0.221	0.295	0.203	0.161	0.321	0.284	0.241	0.086	0.496	0.332	0.266	0.296	0.137	0.260	0.263	0.209	0.299	0.156	0.142	0.194
Israel	0.313	0.367	0.257	0.348	0.041	0.416	0.153	0.435	0.421	0.287	0.376	0.226	0.221	1.000	0.463	0.166	0.201	0.425	0.357	0.326	0.105	0.365	0.443	0.402	0.432	0.157	0.181	0.185	0.257	0.427	0.250	0.260	0.294
Italy	0.480	0.702	0.476	0.591	0.088	0.733	0.138	0.901	0.837	0.316	0.608	0.307	0.295	0.463	1.000	0.195	0.364	0.697	0.599	0.376	0.147	0.436	0.641	0.884	0.799	0.450	0.195	0.241	0.370	0.807	0.469	0.398	0.549
Japan	0.472	0.272	0.106	0.191	0.097	0.272	0.178	0.211	0.208	0.440	0.226	0.205	0.203	0.166	0.195	1.000	0.206	0.250	0.226	0.187	0.117	0.461	0.311	0.200	0.236	0.151	0.328	0.269	0.138	0.229	0.046	0.054	0.071
Morocco	0.329	0.407	0.195	0.239	0.122	0.402	0.131	0.327	0.290	0.183	0.331	0.157	0.161	0.201	0.364	0.206	1.000	0.347	0.332	0.251	0.095	0.204	0.316	0.367	0.340	0.348	0.144	0.169	0.166	0.301	0.076	0.061	0.135
Norway	0.557	0.707	0.409	0.583	0.095	0.743	0.176	0.703	0.666	0.382	0.577	0.328	0.321	0.425	0.697	0.250	0.347	1.000	0.537	0.490	0.172	0.501	0.696	0.674	0.731	0.421	0.248	0.272	0.367	0.718	0.333	0.286	0.434
Poland	0.430	0.531	0.307	0.419	0.072	0.586	0.176	0.517	0.504	0.350	0.584	0.289	0.284	0.357	0.599	0.226	0.332	0.537	1.000	0.461	0.152	0.480	0.607	0.519	0.525	0.308	0.235	0.259	0.353	0.521	0.252	0.223	0.313
Russia	0.367	0.410	0.284	0.342	0.102	0.391	0.126	0.398	0.382	0.330	0.436	0.250	0.241	0.326	0.376	0.187	0.251	0.490	0.461	1.000	0.127	0.416	0.471	0.363	0.424	0.165	0.236	0.239	0.326	0.427	0.186	0.164	0.233
Saudi Arabia	0.190	0.179	0.106	0.133	0.088	0.168	0.141	0.141	0.144	0.173	0.148	0.090	0.086	0.105	0.147	0.117	0.095	0.172	0.152	0.127	1.000	0.174	0.142	0.136	0.149	0.107	0.122	0.099	0.108	0.149	0.105	0.076	0.119
Singapore	0.615	0.471	0.368	0.385	0.234	0.504	0.226	0.457	0.425	0.699	0.419	0.499	0.496	0.365	0.436	0.461	0.204	0.501	0.480	0.416	0.174	1.000	0.529	0.445	0.484	0.256	0.477	0.497	0.372	0.491	0.247	0.236	0.309
South Africa	0.611	0.629	0.449	0.546	0.126	0.642	0.178	0.649	0.621	0.447	0.599	0.343	0.332	0.443	0.641	0.311	0.316	0.696	0.607	0.471	0.142	0.529	1.000	0.621	0.656	0.368	0.287	0.302	0.402	0.689	0.321	0.279	0.397
Spain	0.468	0.695	0.431	0.559	0.058	0.727	0.131	0.864	0.788	0.308	0.579	0.275	0.266	0.402	0.884	0.200	0.367	0.674	0.519	0.363	0.136	0.445	0.621	1.000	0.767	0.416	0.186	0.220	0.337	0.776	0.428	0.362	0.508
Sweden	0.499	0.655	0.421	0.585	0.067	0.746	0.132	0.818	0.771	0.359	0.567	0.307	0.296	0.432	0.799	0.236	0.340	0.731	0.525	0.424	0.149	0.484	0.656	0.767	1.000	0.386	0.222	0.247	0.364	0.773	0.422	0.399	0.503
Switzerland	0.320	0.504	0.184	0.310	0.045	0.481	0.099	0.407	0.391	0.112	0.331	0.137	0.137	0.157	0.450	0.151	0.348	0.421	0.308	0.165	0.107	0.256	0.368	0.416	0.386	1.000	0.079	0.101	0.157	0.383	0.156	0.116	0.228
Taiwan	0.378	0.233	0.149	0.183	0.107	0.247	0.135	0.198	0.191	0.400	0.190	0.258	0.260	0.181	0.195	0.328	0.144	0.248	0.235	0.236	0.122	0.477	0.287	0.186	0.222	0.079	1.000	0.280	0.185	0.211	0.085	0.105	0.113
Thailand	0.340	0.250	0.184	0.230	0.095	0.254	0.149	0.224	0.226	0.421	0.241	0.266	0.263	0.185	0.241	0.269	0.169	0.272	0.259	0.239	0.099	0.497	0.302	0.220	0.247	0.101	0.280	1.000	0.197	0.248	0.112	0.109	0.138
Turkey	0.286	0.346	0.272	0.292	0.046	0.369	0.130	0.343	0.340	0.236	0.371	0.220	0.209	0.257	0.370	0.138	0.166	0.367	0.353	0.326	0.108	0.372	0.402	0.337	0.364	0.157	0.185	0.197	1.000	0.356	0.185	0.182	0.227
United Kingdom	0.526	0.668	0.452	0.614	0.069	0.719	0.156	0.840	0.775	0.377	0.556	0.309	0.299	0.427	0.807	0.229	0.301	0.718	0.521	0.427	0.149	0.491	0.689	0.776	0.773	0.383	0.211	0.248	0.356	1.000	0.457	0.385	0.543
USA DJIA	0.184	0.293	0.489	0.618	0.009	0.323	0.068	0.480	0.510	0.177	0.283	0.166	0.156	0.250	0.469	0.046	0.076	0.333	0.252	0.186	0.105	0.247	0.321	0.428	0.422	0.156	0.085	0.112	0.185	0.457	1.000	0.781	0.953
USA Nasdaq	0.149	0.219	0.455	0.614	0.010	0.270	0.051	0.410	0.457	0.168	0.243	0.151	0.142	0.260	0.398	0.054	0.061	0.286	0.223	0.164	0.076	0.236	0.279	0.362	0.399	0.116	0.105	0.109	0.182	0.385	0.781	1.000	0.799
USA NYSE	0.247	0.388	0.536	0.713	0.027	0.416	0.087	0.558	0.572	0.211	0.352	0.204	0.194	0.294	0.549	0.071	0.135	0.434	0.313	0.233	0.119	0.309	0.397	0.508	0.503	0.228	0.113	0.138	0.227	0.543	0.953	0.799	1.000

Table 4.2: Correlation matrix of daily samples (columns) to one day lagged values (rows) between markets.

	Australia	Austria	Brazil	Canada	China	Denmark	Egypt	France	Germany	Hong Kong	Hungary	India BSE100	India SPCNX500	Israel	Italy	Japan	Morocco	Norway	Poland	Russia	Saudi Arabia	Singapore	South Africa	Spain	Sweden	Switzerland	Taiwan	Thailand	Turkey	United Kingdom	USA DJIA	USA Nasdaq	USA NYSE
Australia	0.025	0.052	-0.002	0.023	0.039	-0.016	0.078	-0.035	-0.025	0.055	-0.003	0.046	0.051	0.012	-0.014	0.086	0.026	-0.009	0.022	0.007	0.071	0.029	-0.023	-0.020	-0.021	-0.006	0.118	0.097	0.004	-0.017	-0.025	-0.019	-0.026
Austria	0.185	0.061	0.002	0.043	0.061	0.024	0.167	-0.023	-0.024	0.117	0.033	0.088	0.092	0.032	0.003	0.196	0.064	-0.008	0.052	0.042	0.084	0.131	0.028	-0.005	-0.016	0.002	0.163	0.109	0.016	-0.009	-0.032	-0.034	-0.029
Brazil	0.317	0.172	0.073	0.098	0.060	0.166	0.173	0.111	0.104	0.282	0.201	0.150	0.153	0.147	0.109	0.267	0.127	0.148	0.225	0.197	0.130	0.259	0.235	0.129	0.139	0.043	0.200	0.161	0.107	0.140	-0.036	-0.021	-0.029
Canada	0.409	0.202	0.048	0.079	0.089	0.191	0.182	0.127	0.102	0.317	0.162	0.155	0.154	0.166	0.107	0.325	0.123	0.199	0.204	0.171	0.127	0.287	0.258	0.123	0.166	0.052	0.263	0.196	0.114	0.161	-0.088	-0.059	-0.080
China	-0.026	-0.014	0.003	-0.015	-0.008	-0.027	0.011	-0.028	-0.026	-0.057	-0.016	-0.013	-0.015	-0.028	-0.027	-0.017	-0.019	-0.018	-0.040	-0.031	-0.009	-0.051	-0.029	-0.034	-0.029	0.000	0.009	-0.031	-0.022	-0.023	-0.019	-0.008	-0.019
Denmark	0.206	0.082	0.012	0.046	0.093	0.054	0.160	-0.027	-0.019	0.169	0.028	0.102	0.105	0.035	-0.001	0.224	0.062	0.021	0.048	0.034	0.104	0.154	0.046	-0.010	-0.003	0.011	0.153	0.117	0.007	-0.000	-0.036	-0.027	-0.031
Egypt	0.070	0.041	0.050	0.034	0.022	0.032	0.147	0.018	0.018	0.058	0.047	0.065	0.058	0.023	0.028	0.071	0.079	0.022	0.049	0.033	0.058	0.063	0.011	0.021	0.025	0.011	0.061	0.044	0.050	0.032	0.003	0.022	0.013
France	0.293	0.101	0.013	0.070	0.065	0.081	0.163	-0.005	0.004	0.239	0.061	0.112	0.116	0.073	0.009	0.314	0.064	0.052	0.098	0.063	0.081	0.207	0.101	0.012	0.038	0.011	0.211	0.150	0.041	0.011	-0.019	-0.018	-0.018
Germany	0.292	0.118	0.034	0.082	0.070	0.115	0.162	0.044	-0.004	0.227	0.100	0.136	0.135	0.072	0.050	0.306	0.076	0.074	0.121	0.079	0.083	0.231	0.123	0.051	0.077	0.026	0.223	0.149	0.062	0.055	-0.008	-0.007	-0.006
Hong Kong	0.052	0.058	-0.003	0.027	0.025	0.020	0.064	0.013	0.001	-0.010	0.024	0.037	0.039	0.004	0.042	0.062	0.073	0.015	0.037	-0.004	0.041	-0.019	-0.007	0.023	0.007	0.053	0.119	0.083	0.031	0.022	-0.033	-0.019	-0.028
Hungary	0.181	0.093	0.023	0.024	0.058	0.052	0.146	0.001	-0.007	0.121	0.068	0.080	0.089	0.018	0.023	0.197	0.066	0.026	0.096	0.055	0.074	0.155	0.044	0.027	0.018	0.052	0.148	0.092	0.040	0.017	-0.030	-0.025	-0.026
India BSE100	0.128	0.088	0.017	0.044	0.050	0.061	0.134	0.023	0.030	0.078	0.049	0.097	0.121	0.045	0.035	0.126	0.109	0.045	0.035	0.053	0.068	0.060	0.026	0.029	0.036	0.049	0.144	0.066	0.025	0.021	-0.005	-0.006	-0.006
India SPCNX500	0.123	0.085	0.019	0.052	0.046	0.060	0.137	0.032	0.032	0.078	0.047	0.094	0.105	0.041	0.044	0.124	0.111	0.046	0.027	0.054	0.069	0.058	0.029	0.032	0.042	0.044	0.143	0.058	0.029	0.027	-0.001	0.001	-0.001
Israel	0.166	0.059	0.036	0.038	0.069	0.058	0.141	0.023	0.017	0.122	0.029	0.100	0.099	0.050	0.043	0.148	0.040	0.037	0.040	0.036	0.068	0.172	0.057	0.033	0.048	0.025	0.153	0.092	0.030	0.020	0.013	0.025	0.014
Italy	0.289	0.107	0.026	0.074	0.120	0.076	0.153	0.003	-0.002	0.251	0.066	0.130	0.130	0.073	0.006	0.316	0.055	0.052	0.092	0.055	0.080	0.213	0.089	0.023	0.028	0.012	0.222	0.158	0.035	0.009	-0.013	-0.009	-0.013
Japan	-0.036	-0.004	-0.004	-0.009	-0.001	-0.042	-0.006	-0.036	-0.032	-0.048	-0.031	-0.009	-0.006	-0.009	-0.023	-0.066	0.015	-0.038	-0.001	-0.031	0.027	-0.064	-0.053	-0.032	-0.040	0.008	0.068	0.047	0.008	-0.040	-0.038	-0.027	-0.039
Morocco	0.067	0.079	0.051	0.054	0.075	0.050	0.087	0.037	0.031	0.053	0.016	0.048	0.050	0.041	0.048	0.078	0.219	0.044	0.028	0.076	0.022	0.061	0.014	0.054	0.021	0.006	0.077	0.085	0.060	0.026	-0.006	0.015	0.017
Norway	0.213	0.098	0.003	0.034	0.064	0.047	0.178	-0.019	-0.024	0.148	0.044	0.081	0.080	0.045	0.004	0.223	0.063	0.020	0.075	0.042	0.104	0.148	0.054	-0.001	-0.001	0.003	0.177	0.123	0.014	-0.003	-0.046	-0.032	-0.041
Poland	0.166	0.070	0.018	0.043	0.066	0.046	0.169	0.009	0.010	0.139	0.062	0.082	0.086	0.031	0.015	0.175	0.068	0.034	0.111	0.053	0.083	0.159	0.051	0.014	0.036	0.021	0.145	0.112	0.035	0.013	-0.009	0.003	-0.008
Russia	0.110	0.054	0.040	0.015	0.064	0.038	0.108	-0.010	0.003	0.069	0.031	0.055	0.059	0.028	0.008	0.162	0.077	0.007	0.041	0.048	0.059	0.083	0.017	-0.001	0.010	-0.005	0.118	0.120	0.006	-0.009	0.007	0.018	0.008
Saudi Arabia	0.083	0.091	0.027	0.045	0.010	0.069	0.137	0.061	0.054	0.041	0.048	0.039	0.033	0.071	0.073	0.065	0.062	0.048	0.037	0.060	0.054	0.049	0.026	0.064	0.046	0.043	0.042	0.042	0.041	0.059	0.017	0.007	0.019
Singapore	0.122	0.080	0.000	0.053	0.055	0.041	0.125	0.002	0.010	0.113	0.032	0.092	0.098	0.020	0.024	0.170	0.069	0.029	0.049	0.037	0.081	0.040	0.024	0.010	0.013	0.035	0.180	0.074	0.033	0.012	-0.037	-0.027	-0.028
South Africa	0.200	0.098	0.014	0.039	0.083	0.042	0.152	-0.009	0.002	0.165	0.067	0.117	0.123	0.036	0.006	0.197	0.051	0.032	0.094	0.052	0.120	0.174	0.054	0.007	0.014	0.013	0.205	0.148	0.029	0.013	-0.011	-0.017	-0.011
Spain	0.282	0.112	0.027	0.070	0.068	0.081	0.156	0.008	0.024	0.234	0.077	0.121	0.128	0.064	0.025	0.285	0.067	0.055	0.117	0.064	0.081	0.202	0.099	0.044	0.041	0.023	0.209	0.151	0.049	0.018	-0.016	-0.010	-0.014
Sweden	0.268	0.110	0.003	0.057	0.072	0.084	0.178	0.011	0.021	0.216	0.077	0.119	0.116	0.082	0.025	0.280	0.086	0.065	0.097	0.052	0.087	0.190	0.099	0.028	0.028	0.031	0.203	0.132	0.027	0.023	-0.024	-0.014	-0.022
Switzerland	0.108	0.055	0.017	0.050	0.037	0.032	0.087	-0.003	-0.016	0.101	0.033	0.066	0.068	0.060	0.009	0.114	0.010	0.014	0.048	0.040	0.083	0.121	0.039	0.009	0.005	-0.021	0.103	0.052	0.030	0.019	-0.013	-0.007	-0.007
Taiwan	0.008	0.029	-0.017	0.009	0.013	0.001	0.060	0.008	0.020	-0.018	-0.006	0.040	0.040	-0.009	0.027	0.033	0.053	0.004	0.006	0.026	0.016	-0.029	-0.018	0.007	0.013	0.034	0.046	0.054	0.017	0.006	-0.004	-0.004	-0.004
Thailand	0.058	0.034	-0.012	0.017	0.005	-0.001	0.067	-0.021	-0.019	0.057	0.020	0.037	0.037	0.005	-0.006	0.057	0.028	0.014	0.033	0.010	0.042	0.006	0.000	-0.006	-0.008	0.016	0.110	0.107	0.018	-0.007	-0.019	-0.010	-0.022
Turkey	0.124	0.064	-0.015	0.024	0.051	0.035	0.142	0.002	-0.002	0.078	0.048	0.081	0.082	0.046	0.021	0.116	0.066	0.021	0.049	0.072	0.062	0.097	0.044	0.006	0.021	0.010	0.104	0.082	0.046	0.013	-0.028	-0.014	-0.019
United Kingdom	0.284	0.105	0.012	0.060	0.077	0.085	0.151	-0.008	-0.008	0.255	0.072	0.113	0.112	0.060	0.003	0.306	0.070	0.051	0.085	0.072	0.090	0.200	0.100	0.001	0.038	0.015	0.209	0.147	0.038	-0.002	-0.029	-0.027	-0.026
USA DJIA	0.484	0.262	0.093	0.157	0.062	0.301	0.172	0.250	0.218	0.382	0.260	0.164	0.163	0.220	0.209	0.360	0.157	0.270	0.277	0.215	0.127	0.343	0.343	0.225	0.279	0.115	0.295	0.198	0.179	0.285	-0.063	-0.052	-0.048
USA Nasdaq	0.434	0.220	0.078	0.163	0.067	0.265	0.177	0.237	0.197	0.377	0.244	0.198	0.190	0.227	0.191	0.352	0.146	0.255	0.268	0.218	0.099	0.342	0.311	0.204	0.298	0.089	0.287	0.191	0.184	0.263	-0.051	-0.028	-0.027
USA NYSE	0.519	0.288	0.099	0.170	0.079	0.312	0.209	0.256	0.220	0.396	0.263	0.180	0.177	0.233	0.218	0.387	0.176	0.292	0.280	0.222	0.146	0.356	0.358	0.232	0.281	0.126	0.303	0.210	0.173	0.294	-0.071	-0.057	-0.054

Table 4.3: Correlation matrix based on quarterly samples between markets. Note that the matrix is symmetric.

	Australia	Austria	Brazil	Canada	China	Denmark	Egypt	France	Germany	Hong Kong	Hungary	India BSE100	India SPCNX500	Israel	Italy	Japan	Morocco	Norway	Poland	Russia	Saudi Arabia	Singapore	South Africa	Spain	Sweden	Switzerland	Taiwan	Thailand	Turkey	United Kingdom	USA DJIA	USA Nasdaq	USA NYSE
Australia	1.000	0.834	0.824	0.912	0.613	0.822	0.609	0.737	0.779	0.837	0.720	0.854	0.838	0.864	0.682	0.567	0.678	0.932	0.865	0.702	0.504	0.948	0.837	0.739	0.855	0.566	0.796	0.629	0.595	0.850	0.694	0.658	0.743
Austria	0.834	1.000	0.617	0.744	0.430	0.846	0.701	0.654	0.675	0.557	0.709	0.738	0.732	0.691	0.715	0.531	0.733	0.832	0.833	0.549	0.582	0.809	0.800	0.720	0.686	0.555	0.590	0.566	0.393	0.733	0.455	0.392	0.605
Brazil	0.824	0.617	1.000	0.887	0.610	0.814	0.680	0.625	0.758	0.764	0.591	0.870	0.852	0.835	0.506	0.594	0.682	0.874	0.658	0.796	0.558	0.908	0.770	0.566	0.793	0.538	0.779	0.487	0.802	0.742	0.631	0.662	0.656
Canada	0.912	0.744	0.887	1.000	0.592	0.907	0.734	0.746	0.827	0.857	0.696	0.873	0.853	0.911	0.614	0.625	0.674	0.938	0.847	0.744	0.666	0.917	0.820	0.665	0.885	0.638	0.729	0.540	0.725	0.858	0.744	0.717	0.800
China	0.613	0.430	0.610	0.592	1.000	0.616	0.200	0.551	0.611	0.620	0.533	0.583	0.540	0.524	0.502	0.092	0.768	0.630	0.617	0.487	0.001	0.670	0.332	0.590	0.543	0.533	0.511	0.132	0.345	0.620	0.523	0.329	0.551
Denmark	0.822	0.846	0.814	0.907	0.616	1.000	0.704	0.797	0.871	0.716	0.710	0.789	0.775	0.827	0.759	0.547	0.790	0.884	0.855	0.591	0.611	0.863	0.702	0.780	0.848	0.823	0.640	0.463	0.562	0.893	0.754	0.603	0.873
Egypt	0.609	0.701	0.680	0.734	0.200	0.704	1.000	0.496	0.556	0.567	0.735	0.703	0.697	0.637	0.406	0.711	0.515	0.757	0.757	0.607	0.867	0.595	0.804	0.456	0.606	0.430	0.505	0.336	0.658	0.571	0.390	0.457	0.502
France	0.737	0.654	0.625	0.746	0.551	0.797	0.496	1.000	0.905	0.798	0.539	0.650	0.645	0.737	0.937	0.601	0.763	0.667	0.687	0.412	0.494	0.880	0.540	0.898	0.813	0.733	0.546	0.483	0.525	0.883	0.783	0.784	0.836
Germany	0.779	0.675	0.758	0.827	0.611	0.871	0.556	0.905	1.000	0.760	0.535	0.731	0.715	0.819	0.819	0.554	0.815	0.756	0.710	0.468	0.474	0.890	0.588	0.860	0.834	0.793	0.594	0.541	0.559	0.889	0.810	0.759	0.872
Hong Kong	0.837	0.557	0.764	0.857	0.620	0.716	0.567	0.798	0.760	1.000	0.546	0.785	0.765	0.817	0.670	0.672	0.736	0.776	0.751	0.699	0.429	0.952	0.720	0.677	0.870	0.547	0.676	0.536	0.717	0.807	0.760	0.818	0.715
Hungary	0.720	0.709	0.591	0.696	0.533	0.710	0.735	0.539	0.535	0.546	1.000	0.613	0.598	0.556	0.552	0.246	0.553	0.778	0.803	0.618	0.577	0.781	0.585	0.627	0.638	0.391	0.678	0.138	0.450	0.685	0.504	0.413	0.580
India BSE100	0.854	0.738	0.870	0.873	0.583	0.789	0.703	0.650	0.731	0.785	0.613	1.000	0.996	0.883	0.531	0.711	0.773	0.855	0.780	0.811	0.553	0.913	0.884	0.566	0.762	0.441	0.764	0.666	0.803	0.692	0.487	0.612	0.523
India SPCNX500	0.838	0.732	0.852	0.853	0.540	0.775	0.697	0.645	0.715	0.765	0.598	0.996	1.000	0.873	0.536	0.722	0.753	0.827	0.759	0.797	0.567	0.895	0.882	0.551	0.739	0.408	0.751	0.693	0.802	0.667	0.459	0.604	0.495
Israel	0.864	0.691	0.835	0.911	0.524	0.827	0.637	0.737	0.819	0.817	0.556	0.883	0.873	1.000	0.587	0.660	0.725	0.848	0.751	0.782	0.546	0.915	0.821	0.635	0.852	0.631	0.671	0.594	0.761	0.790	0.664	0.723	0.725
Italy	0.682	0.715	0.506	0.614	0.502	0.759	0.406	0.937	0.819	0.670	0.552	0.531	0.536	0.587	1.000	0.531	0.703	0.580	0.697	0.213	0.397	0.787	0.471	0.918	0.682	0.824	0.466	0.532	0.280	0.832	0.737	0.587	0.849
Japan	0.567	0.531	0.594	0.625	0.092	0.547	0.711	0.601	0.554	0.672	0.246	0.711	0.722	0.660	0.531	1.000	0.589	0.548	0.507	0.648	0.559	0.728	0.749	0.401	0.689	0.325	0.537	0.644	0.742	0.564	0.407	0.702	0.370
Morocco	0.678	0.733	0.682	0.674	0.768	0.790	0.515	0.763	0.815	0.736	0.553	0.773	0.753	0.725	0.703	0.589	1.000	0.725	0.808	0.719	0.292	0.704	0.632	0.821	0.710	0.847	0.480	0.577	0.605	0.695	0.614	0.510	0.656
Norway	0.932	0.832	0.874	0.938	0.630	0.884	0.757	0.667	0.756	0.776	0.778	0.855	0.827	0.848	0.580	0.548	0.725	1.000	0.866	0.769	0.622	0.926	0.859	0.682	0.844	0.616	0.738	0.453	0.662	0.832	0.657	0.591	0.729
Poland	0.865	0.833	0.658	0.847	0.617	0.855	0.757	0.687	0.710	0.751	0.803	0.780	0.759	0.751	0.697	0.507	0.808	0.866	1.000	0.658	0.576	0.901	0.774	0.707	0.769	0.470	0.665	0.470	0.462	0.761	0.548	0.491	0.627
Russia	0.702	0.549	0.796	0.744	0.487	0.591	0.607	0.412	0.468	0.699	0.618	0.811	0.797	0.782	0.213	0.648	0.719	0.769	0.658	1.000	0.484	0.810	0.800	0.355	0.719	0.356	0.723	0.404	0.831	0.608	0.539	0.570	0.479
Saudi Arabia	0.504	0.582	0.558	0.666	0.001	0.611	0.867	0.494	0.474	0.429	0.577	0.553	0.567	0.546	0.397	0.559	0.292	0.622	0.576	0.484	1.000	0.383	0.646	0.371	0.433	0.314	0.302	0.393	0.537	0.443	0.374	0.383	0.506
Singapore	0.948	0.809	0.908	0.917	0.670	0.863	0.595	0.880	0.890	0.952	0.781	0.913	0.895	0.915	0.787	0.728	0.704	0.926	0.901	0.810	0.383	1.000	0.886	0.815	0.950	0.820	0.907	0.711	0.875	0.930	0.872	0.879	0.899
South Africa	0.837	0.800	0.770	0.820	0.332	0.702	0.804	0.540	0.588	0.720	0.585	0.884	0.882	0.821	0.471	0.749	0.632	0.859	0.774	0.800	0.646	0.886	1.000	0.468	0.752	0.451	0.705	0.616	0.725	0.643	0.459	0.575	0.504
Spain	0.739	0.720	0.566	0.665	0.590	0.780	0.456	0.898	0.860	0.677	0.627	0.566	0.551	0.635	0.918	0.401	0.821	0.682	0.707	0.355	0.371	0.815	0.468	1.000	0.738	0.738	0.484	0.414	0.329	0.856	0.755	0.637	0.814
Sweden	0.855	0.686	0.793	0.885	0.543	0.848	0.606	0.813	0.834	0.870	0.638	0.762	0.739	0.852	0.682	0.689	0.710	0.844	0.769	0.719	0.433	0.950	0.752	0.738	1.000	0.705	0.773	0.511	0.709	0.931	0.855	0.869	0.835
Switzerland	0.566	0.555	0.538	0.638	0.533	0.823	0.430	0.733	0.793	0.547	0.391	0.441	0.408	0.631	0.824	0.325	0.847	0.616	0.470	0.356	0.314	0.820	0.451	0.738	0.705	1.000	0.303	0.218	0.344	0.788	0.746	0.577	0.858
Taiwan	0.796	0.590	0.779	0.729	0.511	0.640	0.505	0.546	0.594	0.676	0.678	0.764	0.751	0.671	0.466	0.537	0.480	0.738	0.665	0.723	0.302	0.907	0.705	0.484	0.773	0.303	1.000	0.482	0.658	0.711	0.564	0.663	0.537
Thailand	0.629	0.566	0.487	0.540	0.132	0.463	0.336	0.483	0.541	0.536	0.138	0.666	0.693	0.594	0.532	0.644	0.577	0.453	0.470	0.404	0.393	0.711	0.616	0.414	0.511	0.218	0.482	1.000	0.374	0.425	0.336	0.481	0.316
Turkey	0.595	0.393	0.802	0.725	0.345	0.562	0.658	0.525	0.559	0.717	0.450	0.803	0.802	0.761	0.280	0.742	0.605	0.662	0.462	0.831	0.537	0.875	0.725	0.329	0.709	0.344	0.658	0.374	1.000	0.578	0.506	0.737	0.447
United Kingdom	0.850	0.733	0.742	0.858	0.620	0.893	0.571	0.883	0.889	0.807	0.685	0.692	0.667	0.790	0.832	0.564	0.695	0.832	0.761	0.608	0.443	0.930	0.643	0.856	0.931	0.788	0.711	0.425	0.578	1.000	0.898	0.809	0.928
USA DJIA	0.694	0.455	0.631	0.744	0.523	0.754	0.390	0.783	0.810	0.760	0.504	0.487	0.459	0.664	0.737	0.407	0.614	0.657	0.548	0.539	0.374	0.872	0.459	0.755	0.855	0.746	0.564	0.336	0.506	0.898	1.000	0.865	0.939
USA Nasdaq	0.658	0.392	0.662	0.717	0.329	0.603	0.457	0.784	0.759	0.818	0.413	0.612	0.604	0.723	0.587	0.702	0.510	0.591	0.491	0.570	0.383	0.879	0.575	0.637	0.869	0.577	0.663	0.481	0.737	0.809	0.865	1.000	0.762
USA NYSE	0.743	0.605	0.656	0.800	0.551	0.873	0.502	0.836	0.872	0.715	0.580	0.523	0.495	0.725	0.849	0.370	0.656	0.729	0.627	0.479	0.506	0.899	0.504	0.814	0.835	0.858	0.537	0.316	0.447	0.928	0.939	0.762	1.000

The correlation analysis using daily basis data with each of the markets lagged by one day can be seen in Table 4.2. It can be seen that the correlations are generally significantly lower compared to the unlagged correlations. The Australian market however, has higher correlations to the American markets when the data is lagged, 0.484 towards DJIA, 0.434 towards Nasdaq and 0.519 towards NYSE compared to 0.184, 0.149 and 0.247 respectively for the unlagged correlations. Similar patterns can also be observed for Japan, Hong Kong and Taiwan. The unlagged correlation between Japan and USA is practically zero, while the lagged correlations range between 0.352 to 0.387. Generally, the lagged markets exhibit a higher correlation towards the American, Brazilian and Canadian markets compared to the other markets.

The correlation matrix for the markets based on observations on a quarterly basis can be seen in Table 4.3. It can be seen that the overall correlations are significantly higher compared to the daily and lagged correlations. The markets of China, Egypt and Saudi Arabia are as for the daily correlation analysis generally less correlated to the other markets. Singapore exhibits very high correlations towards most of the other markets, with correlation coefficients generally above 0.85. The United Kingdom are also found to be highly correlated to the rest of the examined markets.

For the case of Sweden, the highest quarterly correlations are found towards Singapore and the United Kingdom, with coefficient of 0.950 and 0.931 respectively. Major industrial, European countries along with the American, Canadian and Brazil markets, are all markets which exhibits high correlations towards Sweden. The lowest correlations regarding Sweden are towards Saudi Arabia (0.433), Thailand (0.511) and China (0.533).

Likewise the daily correlation analysis, countries with multiple domestic markets experience very high internal correlations. The overall lowest correlations can be found between China and Saudi Arabia (0.001), China and Japan (0.092) and China and Egypt (0.200).

4.4.2 Commodities - Commodities

The calculated correlations between commodities based on daily data can be seen in Table 4.4. The correlations for the commodities are overall relatively low. Exceptions are between the metals Aluminum, Copper, Nickel and Zinc, with coefficients ranging from 0.566 to 0.667. Gold, Silver and Platinum also indicate signs of correlation, with coefficients ranging from 0.397 to 0.452. Commodities with near zero correlation towards the other commodities are Coal, Cocoa, Coffee, Lumber, Natural Gas and Uranium. For all of these commodities except Coffee, the indices are updated less frequently than daily. The correlations for those commodities are therefore not accurate and should not be considered for the daily analysis. However, the quarterly analyses for those commodities are valid. Wheat and Cotton also show relatively low correlations towards the other commodities.

For the quarterly analysis of the commodities, the correlations can be seen in Table 4.5. Generally, the coefficients show no clear overall trend. Cocoa shows an uncorrelated relationship to most of the other commodities. The correlation between Natural Gas and the other commodities are spread, from -0.357 towards Coffee to 0.531 towards Platinum. As for the daily analysis, Aluminum, Zinc, Nickel and Copper exhibit high internal correlation coefficients. While Aluminum, Zinc and Nickel are relatively uncorrelated towards the other commodities, Copper is more correlated. Other commodities which show relatively high correlations in general are Cotton, Gold, Oil, Platinum and Silver.

Table 4.4: Correlation matrix based on daily samples between commodities. Note that the matrix is symmetric.

	Aluminium	Coal	Cocoa	Coffee	Copper	Cotton	Gold	Lumber	Natural Gas	Nickel	Oil	Platinum	Silver	Sugar	Uranium	Wheat	Zinc
Aluminium	1.000	0.056	-0.005	0.007	0.662	0.152	0.240	0.017	0.042	0.508	0.190	0.197	0.149	0.062	0.005	0.120	0.611
Coal	0.056	1.000	0.018	-0.008	0.029	0.056	-0.012	-0.015	-0.005	0.023	0.016	0.042	0.004	0.029	0.009	0.033	0.021
Cocoa	-0.005	0.018	1.000	0.059	-0.022	-0.003	0.012	0.027	0.008	0.001	0.002	0.023	0.058	-0.015	-0.011	-0.030	-0.022
Coffee	0.007	-0.008	0.059	1.000	-0.002	0.010	0.026	0.028	0.004	0.016	0.017	0.066	0.070	0.024	-0.008	0.011	0.021
Copper	0.662	0.029	-0.022	-0.002	1.000	0.173	0.272	0.011	0.032	0.566	0.229	0.207	0.153	0.093	0.016	0.142	0.667
Cotton	0.152	0.056	-0.003	0.010	0.173	1.000	0.101	-0.013	0.051	0.139	0.119	0.084	0.041	0.063	0.020	0.180	0.143
Gold	0.240	-0.012	0.012	0.026	0.272	0.101	1.000	-0.012	0.059	0.184	0.175	0.397	0.434	0.021	-0.002	0.098	0.248
Lumber	0.017	-0.015	0.027	0.028	0.011	-0.013	-0.012	1.000	-0.017	-0.029	-0.029	-0.010	-0.040	-0.009	0.000	-0.026	-0.011
Natural Gas	0.042	-0.005	0.008	0.004	0.032	0.051	0.059	-0.017	1.000	0.026	0.106	0.072	0.085	0.031	0.017	0.009	0.038
Nickel	0.508	0.023	0.001	0.016	0.566	0.139	0.184	-0.029	0.026	1.000	0.183	0.151	0.121	0.072	0.004	0.097	0.533
Oil	0.190	0.016	0.002	0.017	0.229	0.119	0.175	-0.029	0.106	0.183	1.000	0.151	0.126	0.068	-0.013	0.109	0.206
Platinum	0.197	0.042	0.023	0.066	0.207	0.084	0.397	-0.010	0.072	0.151	0.151	1.000	0.452	0.046	-0.020	0.071	0.194
Silver	0.149	0.004	0.058	0.070	0.153	0.041	0.434	-0.040	0.085	0.121	0.126	0.452	1.000	0.016	0.011	0.045	0.151
Sugar	0.062	0.029	-0.015	0.024	0.093	0.063	0.021	-0.009	0.031	0.072	0.068	0.046	0.016	1.000	0.006	0.057	0.071
Uranium	0.005	0.009	-0.011	-0.008	0.016	0.020	-0.002	0.000	0.017	0.004	-0.013	-0.020	0.011	0.006	1.000	0.020	0.015
Wheat	0.120	0.033	-0.030	0.011	0.142	0.180	0.098	-0.026	0.009	0.097	0.109	0.071	0.045	0.057	0.020	1.000	0.118
Zinc	0.611	0.021	-0.022	0.021	0.667	0.143	0.248	-0.011	0.038	0.533	0.206	0.194	0.151	0.071	0.015	0.118	1.000

Table 4.5: Correlation matrix based on quarterly samples between commodities. Note that the matrix is symmetric.

	Aluminium	Coal	Cocoa	Coffee	Copper	Cotton	Gold	Lumber	Natural Gas	Nickel	Oil	Platinum	Silver	Sugar	Uranium	Wheat	Zinc
Aluminium	1.000	0.151	-0.085	0.552	0.872	0.394	0.282	0.570	-0.017	0.738	0.477	0.568	0.478	0.515	0.381	0.134	0.794
Coal	0.151	1.000	0.012	0.392	0.342	0.474	0.545	-0.021	0.131	0.330	0.343	0.522	0.406	0.107	0.408	0.773	0.065
Cocoa	-0.085	0.012	1.000	-0.048	0.018	0.040	0.197	-0.068	-0.136	-0.147	-0.065	-0.037	0.057	0.187	0.049	0.202	-0.010
Coffee	0.552	0.392	-0.048	1.000	0.450	0.344	0.249	0.526	-0.357	0.327	0.247	0.135	0.411	0.295	0.337	0.208	0.308
Copper	0.872	0.342	0.018	0.450	1.000	0.573	0.620	0.576	0.043	0.693	0.615	0.715	0.657	0.625	0.408	0.293	0.791
Cotton	0.394	0.474	0.040	0.344	0.573	1.000	0.589	0.677	0.204	0.456	0.364	0.674	0.648	0.396	0.186	0.531	0.312
Gold	0.282	0.545	0.197	0.249	0.620	0.589	1.000	0.122	0.025	0.385	0.555	0.528	0.639	0.315	0.464	0.584	0.356
Lumber	0.570	-0.021	-0.068	0.526	0.576	0.677	0.122	1.000	0.317	0.187	0.462	0.531	0.407	0.576	-0.173	0.043	0.187
Natural Gas	-0.017	0.131	-0.136	-0.357	0.043	0.204	0.025	0.317	1.000	-0.063	0.158	0.531	-0.116	0.357	-0.109	0.051	-0.066
Nickel	0.738	0.330	-0.147	0.327	0.693	0.456	0.385	0.187	-0.063	1.000	0.409	0.531	0.536	0.072	0.517	0.316	0.779
Oil	0.477	0.343	-0.065	0.247	0.615	0.364	0.555	0.462	0.158	0.409	1.000	0.640	0.382	0.277	0.273	0.325	0.374
Platinum	0.568	0.522	-0.037	0.135	0.715	0.674	0.528	0.531	0.531	0.531	0.640	1.000	0.497	0.519	0.201	0.392	0.483
Silver	0.478	0.406	0.057	0.411	0.657	0.648	0.639	0.407	-0.116	0.536	0.382	0.497	1.000	0.410	0.584	0.550	0.630
Sugar	0.515	0.107	0.187	0.295	0.625	0.396	0.315	0.576	0.357	0.072	0.277	0.519	0.410	1.000	0.059	0.038	0.432
Uranium	0.381	0.408	0.049	0.337	0.408	0.186	0.464	-0.173	-0.109	0.517	0.273	0.201	0.584	0.059	1.000	0.516	0.549
Wheat	0.134	0.773	0.202	0.208	0.293	0.531	0.584	0.043	0.051	0.316	0.325	0.392	0.550	0.038	0.516	1.000	0.093
Zinc	0.794	0.065	-0.010	0.308	0.791	0.312	0.356	0.187	-0.066	0.779	0.374	0.483	0.630	0.432	0.549	0.093	1.000

4.4.3 Market - Commodities

The resulting correlation matrix for the daily analysis between markets and commodities can be seen in Table 4.6. As mentioned before should the daily data for Coal, Cocoa, Coffee, Lumber, Natural Gas and Uranium not be considered to any larger extent. The

four metals Aluminum, Copper, Nickel and Zinc are the commodities exhibiting the highest correlations toward the market indices. Oil, Gold, Silver and Platinum show slightly lower correlations overall. Practically zero correlation can be seen between Gold and the American markets. The highest correlation can be found between the market of United Kingdom and Copper at 0.409. Canada, Denmark, Norway and South Africa are among the markets showing highest correlations towards the commodities. For the case of Sweden, the largest correlations are found towards Copper and Zinc.

Table 4.6: Correlation matrix based on daily samples between markets and commodities.

	Aluminium	Coal	Cocoa	Coffee	Copper	Cotton	Gold	Lumber	Natural Gas	Nickel	Oil	Platinum	Silver	Sugar	Uranium	Wheat	Zinc
Australia	0.256	0.016	0.028	0.049	0.317	0.129	0.247	0.014	0.055	0.230	0.209	0.287	0.256	0.067	-0.017	0.099	0.279
Austria	0.293	0.018	0.037	0.046	0.353	0.147	0.185	0.010	0.033	0.242	0.219	0.214	0.183	0.057	0.010	0.119	0.308
Brazil	0.203	0.003	0.016	0.049	0.239	0.115	0.055	-0.000	0.019	0.175	0.124	0.101	0.069	0.069	-0.005	0.090	0.204
Canada	0.322	0.043	0.014	0.047	0.374	0.190	0.188	0.004	0.059	0.270	0.259	0.205	0.139	0.077	0.005	0.166	0.311
China	0.038	-0.018	0.026	0.005	0.062	0.034	0.035	-0.007	-0.003	0.046	0.022	0.072	0.055	0.004	0.001	0.027	0.048
Denmark	0.311	0.020	0.023	0.038	0.368	0.163	0.178	-0.006	0.035	0.267	0.242	0.202	0.174	0.068	0.010	0.128	0.329
Egypt	0.058	0.045	0.032	0.017	0.076	0.053	0.034	0.027	-0.005	0.059	0.090	0.107	0.063	0.000	0.012	0.001	0.076
France	0.314	0.008	-0.009	0.030	0.371	0.159	0.098	-0.004	0.029	0.270	0.195	0.157	0.108	0.064	0.016	0.132	0.327
Germany	0.299	0.013	-0.005	0.043	0.346	0.151	0.091	0.013	0.022	0.249	0.168	0.149	0.103	0.059	0.013	0.136	0.293
Hong Kong	0.131	-0.014	0.047	0.020	0.178	0.050	0.060	0.020	0.021	0.125	0.110	0.169	0.132	0.037	-0.019	0.042	0.151
Hungary	0.244	0.021	0.002	0.017	0.286	0.110	0.128	0.025	0.040	0.214	0.188	0.160	0.147	0.047	0.016	0.093	0.261
India BSE100	0.151	0.003	-0.005	0.011	0.177	0.082	0.085	0.057	0.039	0.154	0.101	0.141	0.137	0.026	0.038	0.060	0.171
India SPCNX500	0.150	0.001	-0.000	0.016	0.179	0.083	0.085	0.053	0.041	0.153	0.101	0.140	0.143	0.030	0.043	0.059	0.175
Israel	0.177	0.026	-0.001	0.008	0.202	0.075	0.039	0.008	0.021	0.151	0.115	0.111	0.090	0.028	0.006	0.064	0.190
Italy	0.340	0.008	-0.000	0.043	0.405	0.183	0.112	-0.004	0.041	0.274	0.217	0.162	0.128	0.082	0.011	0.145	0.332
Japan	0.117	-0.002	0.051	0.053	0.116	0.024	0.159	0.036	0.015	0.088	0.090	0.163	0.131	0.046	0.024	0.034	0.118
Morocco	0.176	0.001	0.019	0.055	0.194	0.118	0.217	-0.004	0.049	0.131	0.152	0.214	0.164	0.072	0.011	0.109	0.141
Norway	0.340	0.044	0.008	0.028	0.405	0.180	0.245	-0.004	0.076	0.280	0.334	0.252	0.228	0.072	0.013	0.147	0.361
Poland	0.235	0.034	0.022	0.055	0.282	0.106	0.147	0.020	0.021	0.195	0.201	0.172	0.155	0.051	-0.004	0.106	0.245
Russia	0.196	0.027	0.023	0.009	0.254	0.107	0.105	-0.000	0.046	0.184	0.172	0.152	0.147	0.023	0.010	0.084	0.216
Saudi Arabia	0.032	0.001	0.027	0.017	0.040	0.048	-0.003	-0.030	0.011	0.046	0.099	0.075	0.079	0.030	0.010	0.032	-0.006
Singapore	0.230	0.002	0.038	0.048	0.291	0.094	0.122	0.031	0.037	0.205	0.179	0.217	0.222	0.023	0.016	0.068	0.264
South Africa	0.339	0.025	0.023	0.042	0.406	0.159	0.273	0.011	0.063	0.284	0.228	0.264	0.243	0.074	0.009	0.146	0.349
Spain	0.298	0.011	-0.002	0.032	0.349	0.155	0.117	-0.005	0.026	0.253	0.182	0.155	0.114	0.063	0.001	0.132	0.306
Sweden	0.308	0.013	0.009	0.019	0.361	0.161	0.124	0.015	0.030	0.265	0.206	0.171	0.141	0.064	0.012	0.124	0.312
Switzerland	0.218	0.014	-0.003	0.011	0.256	0.098	0.217	-0.019	0.035	0.182	0.157	0.156	0.138	0.053	-0.020	0.117	0.215
Taiwan	0.110	0.022	0.083	0.037	0.134	0.059	0.047	-0.001	0.008	0.097	0.072	0.145	0.121	0.037	-0.006	0.019	0.134
Thailand	0.112	0.006	0.031	0.037	0.134	0.044	0.064	0.005	0.023	0.102	0.090	0.131	0.156	0.012	-0.016	0.048	0.122
Turkey	0.147	0.023	-0.026	0.013	0.191	0.066	0.050	0.031	0.018	0.143	0.092	0.076	0.077	0.021	0.001	0.056	0.176
United Kingdom	0.330	0.013	-0.002	0.026	0.409	0.170	0.127	0.016	0.035	0.282	0.231	0.186	0.137	0.073	0.018	0.143	0.349
USA DJIA	0.172	0.028	-0.023	0.020	0.207	0.106	-0.052	0.019	0.004	0.144	0.054	0.054	-0.019	0.043	0.005	0.082	0.163
USA Nasdaq	0.155	0.016	-0.015	0.012	0.180	0.088	-0.035	0.008	0.001	0.121	0.064	0.055	-0.006	0.048	0.014	0.077	0.142
USA NYSE	0.226	0.032	-0.015	0.024	0.269	0.144	-0.001	0.007	0.022	0.191	0.114	0.089	0.013	0.069	0.007	0.120	0.222

The correlation on a quarterly basis between markets and commodities can be seen in Table 4.7. Generally high correlations towards all markets are observed for Aluminum, Copper, Nickel, Oil, Platinum, Silver and Zinc. Coal, Coffee, Cotton, Gold, Lumber, Sugar, Uranium and Wheat have all average correlation coefficients towards the markets. The two major exceptions Cocoa and Natural Gas show scattered results. For Cocoa, practically all correlations are negative or close to zero. The correlation between Cocoa and Japan and the American markets, especially Nasdaq, are relatively highly negative. Natural Gas is relatively uncorrelated to all markets except Taiwan, towards which a negative correlation of 0.346 is observed.

Australia, Austria, Brazil, Canada, Denmark, India, Israel, Norway, Russia, Singapore, South Africa, Sweden and Taiwan have all relatively high correlations towards the examined commodities, apart from the two exceptions Cocoa and Natural Gas. China and Spain are found among the markets showing lowest overall correlations toward the commodities.

Table 4.7: Correlation matrix based on quarterly samples between markets and commodities.

	Aluminium	Coal	Cocoa	Coffee	Copper	Cotton	Gold	Lumber	Natural Gas	Nickel	Oil	Platinum	Silver	Sugar	Uranium	Wheat	Zinc
Australia	0.642	0.484	0.009	0.340	0.848	0.453	0.598	0.489	-0.015	0.616	0.670	0.683	0.646	0.363	0.473	0.356	0.688
Austria	0.654	0.449	0.077	0.452	0.761	0.424	0.509	0.434	-0.045	0.612	0.422	0.612	0.614	0.361	0.612	0.297	0.688
Brazil	0.710	0.501	-0.053	0.468	0.777	0.442	0.470	0.365	-0.013	0.627	0.624	0.638	0.555	0.365	0.393	0.310	0.623
Canada	0.615	0.536	-0.174	0.410	0.770	0.513	0.532	0.512	0.115	0.563	0.696	0.714	0.672	0.382	0.495	0.358	0.606
China	0.355	0.521	0.161	0.168	0.446	0.302	0.369	-0.087	0.123	0.487	0.420	0.549	0.463	0.178	0.401	0.462	0.569
Denmark	0.716	0.539	-0.172	0.562	0.710	0.495	0.390	0.405	0.109	0.625	0.438	0.680	0.675	0.349	0.565	0.334	0.663
Egypt	0.686	0.346	-0.179	0.639	0.628	0.194	0.391	0.224	-0.044	0.353	0.562	0.434	0.457	0.397	0.608	0.137	0.479
France	0.432	0.284	-0.293	0.147	0.506	0.196	0.224	0.289	0.026	0.458	0.357	0.523	0.400	0.065	0.292	0.078	0.545
Germany	0.418	0.516	-0.223	0.324	0.536	0.329	0.366	0.231	-0.105	0.493	0.334	0.492	0.585	0.080	0.416	0.314	0.517
Hong Kong	0.491	0.443	-0.241	0.155	0.634	0.343	0.439	0.370	0.115	0.547	0.734	0.626	0.457	0.123	0.378	0.313	0.538
Hungary	0.462	0.333	0.205	0.472	0.534	0.178	0.259	0.459	-0.039	0.306	0.509	0.413	0.391	0.371	0.382	0.009	0.531
India BSE100	0.643	0.569	-0.061	0.414	0.779	0.533	0.625	0.350	-0.070	0.689	0.727	0.724	0.618	0.270	0.453	0.359	0.620
India SPCNX500	0.629	0.566	-0.071	0.402	0.765	0.527	0.614	0.377	-0.071	0.679	0.714	0.722	0.580	0.252	0.413	0.323	0.586
Israel	0.547	0.514	-0.192	0.228	0.724	0.455	0.485	0.490	0.040	0.629	0.599	0.684	0.674	0.271	0.421	0.306	0.605
Italy	0.527	0.253	-0.236	0.141	0.543	0.204	0.181	0.280	0.073	0.442	0.189	0.530	0.308	0.144	0.242	0.060	0.545
Japan	0.606	0.183	-0.522	0.310	0.581	0.311	0.309	0.559	-0.142	0.612	0.536	0.428	0.354	0.014	0.349	0.049	0.494
Morocco	0.522	0.707	0.042	0.384	0.553	0.357	0.575	-0.201	-0.043	0.768	0.336	0.604	0.618	0.078	0.804	0.601	0.619
Norway	0.708	0.503	-0.019	0.487	0.839	0.414	0.560	0.388	0.038	0.625	0.689	0.669	0.679	0.457	0.582	0.352	0.732
Poland	0.492	0.566	-0.041	0.364	0.676	0.379	0.538	0.306	0.023	0.509	0.580	0.577	0.593	0.318	0.639	0.312	0.647
Russia	0.780	0.227	-0.029	0.308	0.725	0.311	0.463	0.346	-0.049	0.742	0.750	0.543	0.587	0.217	0.560	0.263	0.683
Saudi Arabia	0.505	0.293	-0.200	0.470	0.508	0.174	0.380	0.343	0.176	0.127	0.492	0.450	0.326	0.417	0.424	0.072	0.209
Singapore	0.824	0.503	-0.045	0.576	0.903	0.573	0.608	0.496	-0.165	0.713	0.686	0.653	0.803	0.437	0.462	0.424	0.752
South Africa	0.850	0.435	-0.106	0.540	0.891	0.501	0.639	0.556	-0.066	0.675	0.750	0.669	0.674	0.432	0.504	0.337	0.662
Spain	0.323	0.298	-0.045	0.135	0.442	0.103	0.271	0.037	-0.065	0.420	0.247	0.388	0.387	0.019	0.405	0.104	0.563
Sweden	0.632	0.354	-0.290	0.401	0.701	0.386	0.348	0.531	-0.064	0.686	0.565	0.518	0.623	0.164	0.482	0.222	0.698
Switzerland	0.386	0.338	-0.206	0.218	0.434	0.357	0.191	0.285	0.170	0.449	0.172	0.505	0.604	0.219	0.325	0.273	0.534
Taiwan	0.697	0.243	0.053	0.538	0.750	0.410	0.358	0.661	-0.346	0.582	0.566	0.412	0.529	0.284	0.291	0.145	0.652
Thailand	0.337	0.467	-0.143	0.193	0.569	0.569	0.652	0.635	-0.161	0.534	0.375	0.462	0.424	-0.036	0.245	0.356	0.272
Turkey	0.604	0.285	-0.273	0.364	0.555	0.252	0.252	0.506	-0.067	0.558	0.724	0.510	0.367	0.111	0.247	0.118	0.428
United Kingdom	0.571	0.316	-0.212	0.359	0.625	0.301	0.256	0.465	-0.068	0.576	0.465	0.509	0.587	0.151	0.441	0.206	0.668
USA DJIA	0.346	0.263	-0.248	0.219	0.413	0.196	0.179	0.498	-0.026	0.404	0.395	0.326	0.460	-0.025	0.315	0.218	0.427
USA Nasdaq	0.418	0.137	-0.390	0.233	0.456	0.197	0.176	0.720	-0.187	0.451	0.507	0.313	0.384	-0.084	0.193	0.054	0.412
USA NYSE	0.410	0.323	-0.169	0.241	0.497	0.278	0.198	0.543	0.075	0.380	0.322	0.458	0.561	0.187	0.353	0.236	0.498

5 Discussion

The results given in Section 4 are discussed and analysed below, both from an international and Swedish perspective. Further, it is presented which limitations that have been present in this study. At last the recommendations for further studies are laid out.

5.1 International Market

From the results from the rate of return analysis it can observed that Brazil, Russia and Turkey possess the highest returns. Common for these countries is that they are developing markets with rapid growth. These markets also exhibit the highest standard deviations, which would imply that the higher returns also involve larger risk rates and these markets therefore end up among the average markets regarding return normalized to standard deviation. The markets with the worst performance during the examined time period are Italy and Japan. They do however, exhibit a relatively high standard deviation, which would suggest that they have been a poor choice of investment during the past two decades. The analysis suggests that the market with the highest return contra risk is Morocco which therefore can be seen as a wise investment during the examined time period.

The prominent commodities in terms of rate of return have been those connected to the energy sector, especially Natural Gas. However, Oil has been the better choice of investment when the rate of return is compared to the rate of risk, i.e. standard deviation. The commodity with the highest return contra risk is however Gold making it a reliable investment when the return is measured against risk. The worst performing commodity has been Lumber, with a negative rate of return also resulting in a poor return contra risk ratio.

From the correlation analysis one can clearly see that the western world is relatively highly correlated. Neighbouring countries generally show signs of higher correlations. This might be due to the higher level of integration in the economic systems. For the case of the daily correlations, markets located in similar time zones have overlapping opening hours and information is concurrently known for the traders. Correlation coefficients for USA towards the most eastern countries are overall low on daily basis. If instead the lagged values were used for USA, much higher correlation towards the most eastern countries are observed. This is indicating that the American markets are influencing the movements in the eastern markets to a much larger extent than vice versa. Similar tendencies can be seen for the Brazilian and the Canadian markets towards the most eastern markets, but not to the same extent. The three countries China, Egypt and Saudi Arabia generally exhibit very low correlations towards the rest of the markets during the examined period. For the case of China, this can be due to that international investors were not allowed to trade the dominating type A shares at the Chinese market until 2001. Thereafter trade was allowed but with certain limitations. China, Egypt and Saudi Arabia are all countries which during

the examined period have been relatively closed and less democratic compared to many other markets.

Metals often used together in forming alloys, i.e. Aluminum, Copper, Nickel and Zinc, exhibit high correlations towards each other. More precious metals such as Gold, Silver and Platinum also show relatively high internal correlations. The correlations between those groups of metals are generally lower. Both daily and quarterly data suggests that metals which are commonly used in the industry have high correlations to the markets. Those metals are consumed to a higher degree during better economic situations which results in higher commodity prices due to the increased demand. Gold is the metal which shows the lowest correlation towards the markets. This may be due to the use of gold as an investment rather than a raw material in manufacturing. Natural Gas shows little correlation towards the markets. Natural Gas is to a large extent used for heating and other residential usages, which are less dependent on the market and more on seasonal factors, e.g. weather. The correlation analysis between the markets and the commodities suggests that the markets of Australia, Austria, Brazil, Canada, Denmark, India, Israel, Norway, Russia, Singapore, South Africa, Sweden and Taiwan are highly connected to the examined commodities. Many of those countries are major exporters of raw material. An interesting observations is the relatively negative correlation between Cacao and most of the examined markets. The correlations towards Nikkei225 and NASDAQ amounts to -0.522 and -0.390 respectively. One interesting thought is that the consumption of chocolate increases in rough economic times.

5.2 Swedish Perspective

The rate of return for Sweden has been among the average performers during the examined period. The standard deviation for the Swedish market is also in the average range. These results indicates that the Swedish market has been a stable and relatively secure investment. Generally it exhibits high correlations towards the western European markets, especially France on a daily basis. This is most likely due to the small geographical distances and well developed trade. On a quarterly basis United Kingdom and Singapore are the countries which show the highest correlation towards Sweden. It is interesting that an asian country exhibits such a high correlation towards Sweden. Among the commodities, the metals Zinc and Copper are highest correlated to the Swedish market. This might be due to the use of these metals in the industry as well as that they are mined in Sweden.

5.3 Limitations

It is not possible to fully explain reasons behind the correlations obtained from the analyses. One can just propose that relations exist based on the examined data. No further investigations of these relations have been conducted. Changes in the correlations over

time have not been examined, only the average for the examined time period. The analyses have been limited to only include daily and quarterly data. Interesting correlations occurring for other time intervals have not been investigated. Individual industry branches are not considered in the study, only the whole market indices.

5.4 Recommendations

It would be interesting to deeply analyse why these observed relationships exist by doing further studies. Another interesting topic would be to examine if the correlations has changed over time, i.e. are correlations increasing with globalisation. Lisa Johansson [21] examined changes in correlations of markets over time, one can apply a similar methodology when analyzing correlations of commodities. By analyzing correlations in branches and individual stocks within the market indices one might find more specific relations instead of the more general relations presented in this study. By using e.g. weekly or monthly data different correlations might be found. The obtained results could be used in order to lower risk by risk diversification.

References

[1] Bloomberg. Tadawul All Share TASI Index, November 2012. http://www.bloomberg.com/quote/SASEIDX:IND.

[2] BM&F Bovespa. Bovespa Index - Ibovespa, November 2012. http://www.bmfbovespa.com.br/indices/ResumoIndice.aspx?Indice=Ibovespa&Idioma=en-us.

[3] Bolsa de Madrid. Technical Rules for The Composition, Classification by Sectors and Calculation of the IGBM Family of Indices, November 2012. http://www.bolsamadrid.es/docs/Indices/BMadrid/NormasIGMBINGLESVER_8_june2008_1.pdf.

[4] Bombay Stock Exchange. BSE-100 Index, November 2012. http://www.bseindia.com/indices/DispIndex.aspx?iname=BSE100&sensid=100&type=SENS&graphpath=/applet/images/graf_appBSE100.gif&page=5B6DA9E7-CD6D-48D3-880A-05D1E9E1AA56.

[5] Borsa Italiana - London Stock Exchange Group. Methodology for the Managment of the FTSE MIB Index, November 2012. http://www.borsaitaliana.it/azioni/tutti-gli-indici/metodologiadicalcolo/ftse.en_pdf.htm.

[6] Budapest Stock Exchange. BUX, November 2012. http://bse.hu/topmenu/marketsandproducts/indices/bux.

[7] Casablanca Stock Exchange. Markets Characteristics of indices, November 2012. http://www.casablanca-bourse.com/bourseweb/en/Content.aspx?IdLink=212&Cat=22.

[8] CME Group Inc. Wheat Futures, November 2012. http://www.cmegroup.com/trading/agricultural/grain-and-oilseed/wheat_contractSpecs_futures.html.

[9] Deutsche Börse. Market Data, November 2012. http://www.dax-indices.com/EN/MediaLibrary/Document/Factsheet%20DAX_e.pdf.

[10] Egyptian Exchange. EGX 30 Index Rules", November 2012. http://www.egx.com.eg/getdoc/af3ffc66-152c-4a54-9c95-ddf09f465670/EGX30_Index_Rules.aspx.

[11] R. Falck and J. Lingefjärd. Korrelationer och spridningseffekter mellan olika börser. Bachelor's Thesis, University of Gothenburg, School of Business, Economics and Law, 2009.

[12] FTSE. Factsheet - FTSE All-Share Index, November 2012. http://www.ftse.com/Indices/UK_Indices/Downloads/FTSE_All-Share_Index_Factsheet.pdf.

[13] FTSE. Factsheet - SFTSE/JSE All-Share Index, November 2012. http://www.ftse.com/Indices/FTSE_JSE_Africa_Index_Series/Downloads/J203.pdf.

[14] FTSE. Factsheet - Straits Times Index (STI), November 2012. http://www.ftse.com/Indices/FTSE_ST_Index_Series/Downloads/Straits_Times_Index_Factsheet.pdf.

[15] Hamburg Institute of International Economics. Die Themenfelder Des HWWI, November 2012. http://www.hwwi.org/fileadmin/hwwi_relaunch/themenfelder/HWWI-Themenfelder.pdf.

[16] Hamburg Institute of International Economics. HWWI-Rohstoffpreisindex: Tendenzen frühzeitig erkennen - nachhaltig entscheiden, November 2012. http://hwwi-rohindex.de/index.php?id=7947.

[17] Hang Seng Indexes. Hang Seng Index, November 2012. http://www.hsi.com.hk/HSI-Net/static/revamp/contents/en/dl_centre/brochures/hsi_E.pdf.

[18] IntercontinentalExchange. ICE Brent Crude Oil Frequently-Asked Questions, November 2012. https://www.theice.com/publicdocs/futures/ICE_Brent_FAQ.pdf.

[19] IntercontinentalExchange. Product Specifications, November 2012. https://www.theice.com/productguide/ProductSpec.shtml?specId=219.

[20] International Sugar Organization. Role of ISO, November 2012. http://www.isosugar.org/About/Role.aspx.

[21] Lisa Johansson. Har korrelationen mellan världens marknader? Bachelor's Thesis, University of Gothenburg, School of Business, Economics and Law, 2008.

[22] Lind, D.A. and Marchal, W.G. and Wathen, S.A. *Statistical Techniques in Business & Economics*. McGraw-Hill, 1221 Avenue of the Americas, New York, NY, 10020, Fourteenth edition, 2010.

[23] London Metal Exchange. About the LME, November 2012. http://www.lme.com/who.asp.

[24] London Metal Exchange. Contract Specifications, November 2012. http://www.lme.com/downloads/LME_Contract_Spec_V5_0511_web.pdf.

[25] London Metal Exchange. Contract Specifications LME Copper Summary Specifications, November 2012. http://www.lme.com/copper_contractspec.asp.

[26] London Metal Exchange. Contract Specifications LME Nickel Summary Specifications, November 2012. http://www.lme.com/nickel_contractspec.asp.

[27] London Metal Exchange. Contract Specifications LME Zinc Summary Specifications, November 2012. http://www.lme.com/zinc_contractspec.asp.

[28] London Metal Exchange. Industrial usage Copper Grade A, November 2012. http://www.lme.com/copper_industryusage.asp.

[29] London Metal Exchange. Industrial usage High Grade Primary Aluminium, November 2012. http://www.lme.com/aluminium_industryusage.asp.

[30] London Metal Exchange. Industrial usage High Grade Zinc, November 2012. http://www.lme.com/zinc_industryusage.asp.

[31] London Metal Exchange. Industrial usage Primary Nickel, November 2012. http://www.lme.com/nickel_industryusage.asp.

[32] MICEX Stock Exchange. Composite Indices - Overview, November 2012. http://www.micex.com/marketdata/indices/shares/composite#&index=MICEXINDEXCF.

[33] NASDAQ. NASDAQ Composite Index - Description & Eligibility Criteria for the NASDAQ Composite Index, November 2012. http://www.nasdaq.com/reference/Comp_Eligibility_Criteria.stm.

[34] NASDAQ OMX. Rules for the Construction and Maintenance of the OMX Copenhagen 20 Index, November 2012. https://indexes.nasdaqomx.com/docs/Methodology_OMXC20.pdf.

[35] NASDAQ OMX. Rules for the Construction and Maintenance of the OMX Stockholm 30 Index, November 2012. https://indexes.nasdaqomx.com/docs/Methodology_OMXS30.pdf.

[36] National Stock Exchange of India. S&P CNX 500, November 2012. http://www.nseindia.com/content/indices/ind_cnx_500.pdf.

[37] Nikkei. Nikkei Stock Average Index Guidebook, November 2012. http://indexes.nikkei.co.jp/nkave/archives/file/nikkei_stock_average_guidebook_en.pdf.

[38] NYSE Euronext. Index Rulebook Rules for the CAC 40, November 2012. https://indices.nyx.com/sites/indices.nyx.com/files/cac-family_rules_version_12-02.pdf.

[39] NYSE Euronext. NYSE Composite Index, November 2012. http://www.nyse.com/pdfs/NYSEEuronext_CompIndex.pdf.

[40] Olso Børs. Equity indices, November 2012. http://www.oslobors.no/ob_eng/Oslo-Boers/Products-and-services/Market-data/Indices/Equity-indices/(tab)/1.

[41] Random Lengths Publications Inc. About Random Lenghts, November 2012. http://www.randomlengths.com/Our-Company/About-Random-Lengths/.

[42] Sabine Pipe Line LLC. The Henry Hub, November 2012. http://www.sabinepipeline.com/Home/Report/tabid/241/default.aspx?ID=52.

[43] Shangai Stock Exchange. SSE A Share Index, November 2012. http://www.sse.com.cn/sseportal/en_us/ps/ggxx/zsjbxx.jsp?indexCode=000002&x=9&y=12.

[44] Sharpe, William F. The Sharpe Ratio. *The Journal of Portfolio Management*, 21:49–58, 1994.

[45] SIX Swiss Exchange. SPI Family – Factsheet, November 2012. http://www.six-swiss-exchange.com/index_info/online/share_indices/spi/spifamily_factsheet_en.pdf.

[46] S&P Dow Jones Indices LLC. Dow Jones Industrial Average - Fact Sheet, November 2012. http://www.djindexes.com/mdsidx/downloads/fact_info/Dow_Jones_Industrial_Average_Fact_Sheet.pdf.

[47] Standard & Poor's. S&P GSCI Commodity Indices, November 2012. http://www.standardandpoors.com/indices/articles/en/us/?articleType=PDF&assetID=1245186878016.

[48] Standard & Poor's. S&P/ASX 200 Equity Indices, November 2012. http://www.standardandpoors.com/indices/sp-asx-200/en/us/?indexId=spausta200audff--p-au----.

[49] Tel-Aviv Stock Exchange. TA-100 Index, November 2012. http://www.tase.co.il/TASEEng/MarketData/Indices/MarketCap/IndexAboutTA100.htm?Action=2&addTab=&IndexId=137.

[50] The IntercontinentalExchange. Coffee C Futures, November 2012. https://www.theice.com/productguide/ProductSpec.shtml?specId=15.

[51] The International Cocoa Organization. About ICCO, November 2012. http://www.icco.org/about-us/about-the-icco.html.

[52] The International Cocoa Organization. ICCO Daily Prices of Cocoa Beans, November 2012. http://www.icco.org/statistics/cocoa-prices/daily-prices.html.

[53] The International Cocoa Organization. The Chocolate Industry, November 2012. http://www.icco.org/about-cocoa/chocolate-industry.html.

[54] The Istanbul Stock Exchange. Calculated Indices, November 2012. http://www.ise.org/Indexes/StockIndexesHome/StockIndexesGeneralInfo.aspx.

[55] The London Gold Market Fixing Ltd. London gold fixing, November 2012. http://www.goldfixing.com/.

[56] The London Platinum & Palladium Market. A Brief History, November 2012. http://www.lppm.com/contentitem.aspx?cid=18.

[57] The London Silver Market Fixing Ltd. History, November 2012. http://www.silverfixing.com/.

[58] The Stock Exchange of Thailand. SET Index Series, November 2012. http://www.set.or.th/en/products/index/setindex_p1.html.

[59] The Ux Consulting Comapny. About Uranium Prices, November 2012. http://www.uxc.com/data/uxc_AboutUraniumPrices.aspx.

[60] TWSE. TWSE TAIEX Series Compiled by TWSE, November 2012. http://www.twse.com.tw/en/products/indices/tsec/taiex_1.php.

[61] Warsaw Stock Exchange. WIG - Basic Information, November 2012. http://www.gpw.pl/indeksy_gieldowe_en?isin=PL9999999995&ph_tresc_glowna_start=show.

[62] Wiener Börse. The Rules for the Austrian Indices of the Vienna Stock Exchange, November 2012. http://en.indices.cc/static/cms/sites/indices/media/en/pdf/download/rules/AUT_Index_Guide.pdf.

[63] World Coal Assosiation. Coal Statistics, November 2012. http://www.worldcoal.org/resources/coal-statistics/.